AMERICAN SOCIETY
FOR
TESTING MATERIALS

PROCEEDINGS
OF THE
THIRTY-SIXTH ANNUAL MEETING

Held at Chicago, Illinois
June 26-30, 1933

VOLUME 33
COMMITTEE REPORTS
PART I. NEW AND REVISED TENTATIVE STANDARDS
TENTATIVE REVISIONS OF STANDARDS

Published by
AMERICAN SOCIETY FOR TESTING MATERIALS
260 S. Broad Street, Philadelphia, Pa.

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American Society for Testing Materials

ORGANIZED IN 1898
INCORPORATED IN 1902

PROCEEDINGS, PART I

The Society is not responsible, as a body, for the statements and opinions advanced in this publication.

SUMMARY OF THE PROCEEDINGS OF THE THIRTY-SIXTH ANNUAL MEETING

CHICAGO, ILL., JUNE 26–30, 1933

THE THIRTY-SIXTH ANNUAL MEETING OF THE AMERICAN SOCIETY FOR TESTING MATERIALS was held at The Stevens, Chicago, Ill., June 26–30, 1933. The following is an analysis of the registered attendance at the meeting: Members in attendance or represented, 614; guests, 89; total, 703; ladies, 70. The corresponding statistics for the Thirty-fifth Annual Meeting are: Members in attendance or represented, 588; guests, 86; total, 674; ladies, 82.

THE SECOND EXHIBIT OF TESTING APPARATUS AND EQUIPMENT sponsored by the Society was held in the Exhibition Hall of The Stevens throughout the five days of the annual meeting. In the seventeen booths which comprised the Exhibit there was displayed both industrial and non-commercial apparatus. Nine companies in the industry sponsored booths showing new and improved apparatus they have developed and several research laboratories of educational institutions, associations and companies exhibited apparatus and equipment not produced commercially which was devised for special tests and research work. Five A.S.T.M. committees also participated, some showing equipment they are using in the development of test methods, while others displayed results of research work. Apparatus described in technical papers and reports presented during the meeting was also demonstrated in the Exhibit.

FIRST SESSION—MONDAY, JUNE 26, 9.30 A. M.

Symposium on Cast Iron

(Joint Session with American Foundrymen's Association)

Messrs. Hyman Bornstein and D. M. Avey, co-chairmen.

President Cloyd M. Chapman in opening the Thirty-sixth Annual Meeting directed attention to the many accomplishments and advances in materials standardization which the committees were reporting to the Society this year. Reference was also made to the program replete with many interesting technical papers and the valuable reports on the investigative and cooperative research studies being carried on by the committees. He stated that these accomplishments and contributions were commendable in view of the unusual circumstances and conditions that were experienced during the past year. In referring briefly to the amazing demonstration of progress of the human race during the past century, portrayed at the World's Fair, he called attention to the many contributions made by science and the important service which the Society had rendered in these developments. He pointed to the many contributions made by the Society at this meeting as further evidence of its desire to continue to contribute in advancing this progress during the present century.

The President appointed a Committee of Tellers consisting of H. G. Farmer, chairman, L. S. Marsh and H. H. Morgan to canvass the vote on the election of officers, the report of the tellers to be received in the evening at the Fourth Session.

President Chapman then extended a cordial welcome to the members of the American Foundrymen's Association at this joint session of the A.F.A. and the A.S.T.M. devoted to a Symposium on Cast Iron. This symposium, the third in a series under the auspices of the two societies, was arranged by a joint committee under the chairmanship of Hyman Bornstein.

The President introduced the co-chairmen of the joint session, Hyman Bornstein and D. M. Avey, Vice-President of the A.F.A., the latter representing F. J. Lanahan, President of the American Foundrymen's Association; and then presented the secretary of the session, R. E. Kennedy, Technical Secretary of the A.F.A.

Mr. Bornstein in opening the symposium stated that it had been arranged for the purpose of providing the engineering profession with authoritative data and information on the properties of cast irons produced by the best methods of production. The symposium, devoted to the general engineering properties of cast iron and the metallurgy of cast iron, was then presented under the following topic subjects and, after presentation, was discussed:

Metallurgy of Cast Iron—presented by J. W. Bolton;
Physical Properties of Cast Iron—presented by J. T. MacKenzie;
Machineability and Wear of Cast Iron—in the absence of A. L. Boegehold presented by J. T. MacKenzie;
Corrosion and Corrosion-Resistant Iron Castings and Heat-Resistant Cast Irons—presented by E. K. Smith;
Classification and Specifications for Cast Iron—presented by W. H. Rother;
Heat Treatment of Cast Iron—presented by R. F. Harrington;
White and Chilled Irons—presented by R. S. MacPherran;
Welding of Cast Iron—presented by E. K. Smith;
Recommendations to Designers of Iron Castings—presented by E. K. Smith.

The meeting then adjourned till 2 p. m.

SECOND SESSION—MONDAY, JUNE 26, 2 P. M.

Cast Iron, Effect of Temperature on Metals

(Held Simultaneously with Third Session)

Mr. H. W. Gillett in the chair.

The report of Committee A-7 on Malleable Iron Castings was presented by the Assistant Secretary. The advancement to standard of the tentative revision of the Standard Specifications for Malleable Castings (A 47 – 30), in the form of separate tentative specifications, was approved for reference to letter ballot of the Society for adoption.

The report of Committee A-3 on Cast Iron was presented by the chairman, Hyman Bornstein. The committee withdrew its recommendation for the adoption as standard of the Tentative Specifications for Gray-Iron Castings (A 48 – 32 T) which appeared in the report as preprinted. The committee, however, recommended the withdrawal of the Standard Specifications for Gray-Iron Castings (A 48 – 29) and the Standard Specifications for High-Test Gray-Iron Castings (A 88 – 31) which the tentative specifications are intended to supersede. This recommendation was accepted subject to approval by letter ballot of Committee A-3.[1] In presenting the report Mr. Bornstein called on J. T. MacKenzie to present the report of Subcommittee XV on Impact Testing, which after presentation from manuscript was discussed.

An informal report of the Sectional Committee on Specifications for Cast Iron Pipe and Special Castings was presented by J. T. MacKenzie.

The report of the Joint Research Committee on Effect of Temperature on the Properties of Metals was presented by the chairman, H. J. French. The proposed Tentative Method of Test for Short-Time High-Temperature Tension Tests of Metallic Materials and Method of Test for Long-Time (Creep) High-Temperature Tension Tests of Metallic Materials were accepted for publication as tentative. In presenting the report, Mr. French called on H. F. Moore to present a brief abstract of the cooperative tests in three laboratories carried out in accordance with the short-time high-temperature tension test and which included a discussion of the determination and significance of proportional limit and breaking strength, and the significance of the results of short-time high-temperature tension tests.

A paper entitled "Creep and Structural Stability of Nickel-Chromium-Iron Alloys at 1600 F. (870 C.)," by W. A. Tucker and S. E. Sinclair was presented from manuscript by H. S. Rawdon and discussed.

A paper entitled "Studies on a Modification of the Rohn Test for Investigating Creep of Metals," by C. R. Austin and J. R. Gier was presented by Mr. Austin and discussed.

The meeting then adjourned till 8 p. m.

THIRD SESSION—MONDAY, JUNE 26, 2 P. M.

Preservative Coatings, Electrical Insulating Materials, Rubber, Textiles

(*Held Simultaneously with Second Session*)

President Cloyd M. Chapman in the chair.

The report of Committee D-1 on Preservative Coatings for Structural Materials was presented by the secretary, M. Rea Paul. The proposed Tentative Specifications for Wood to be Used as Panels in Accelerated Weather Tests of Paints and Varnishes, Specifications for Spirits of Turpentine, for Shellac Varnish, for Centrifuged Shellac Varnish, for Industrial 90 per cent Benzene (Benzol), for Industrial Pure Toluene (Toluol), for Industrial Xylene

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[1] The proposed withdrawal of the specifications was submitted to letter ballot of Committee A-3 which consists of 95 members; 59 members returned their ballots, the results being as follows: Specifications A 48, 47 affirmative, 1 negative; Specifications A 88, 46 affirmative and 0 negative.

(Xylol) or Solvent Naphtha, Specifications and Methods of Test for Tricresyl Phosphate, and Tests for Soluble Nitrocellulose Base Solutions were accepted for publication as tentative.

The revision proposed for immediate adoption in the Standard Methods of Sampling and Testing Turpentine (D 233 – 26) was unanimously approved for reference to letter ballot of the Society for adoption as standard, this recommendation requiring a nine-tenths vote. The proposed revision of the Standard Specifications for Basic Carbonate White Lead (D 81 – 31) was accepted for publication as tentative. The proposed revisions of the Tentative Specifications for Soya Bean Oil, Raw or Refined (D 124 – 22 T) and Methods of Testing Nitrocellulose Clear Lacquers and Lacquer Enamels (D 333 – 32 T) were accepted, the specifications and methods as revised being continued as tentative.

The Tentative Specifications for Raw Tung Oil (D 12 – 25 T), for Boiled Linseed Oil (D 260 – 28 T), for Soluble Nitrocellulose (D 301 – 31 T), for Ethyl Acetate (85 to 88 per cent grade) (D 302 – 30 T), for Normal Butyl Acetate (88 to 92 per cent grade) (D 303 – 30 T), for Butanol (Normal Butyl Alcohol) (D 304 – 30 T), for Amyl Acetate (Synthetic) (D 318 – 30 T), for Amyl Alcohol (Synthetic) (D 319 – 30 T), for Butyl Propionate (90 to 93 per cent grade) (D 320 – 30 T), for Ethyl Lactate (Synthetic) (D 321 – 30 T), for Acetone (D 329 – 31 T), for Dry Bleached Shellac (D 207 – 29 T), for Orange Shellac (D 237 – 29 T), for Pure Linseed Oil Putty for Glazing (D 317 – 32 T); also the Tentative Methods of Sampling and Testing Shellac (D 29 – 29 T) and Sampling and Testing Lacquer Solvents and Diluents (D 268 – 31 T) were approved for reference to letter ballot of the Society for adoption as standards.

The tentative revisions of the Standard Methods of Routine Analysis of Dry Red Lead (D 49 – 29), of Yellow, Orange, Red and Brown Pigments Containing Iron and Manganese (D 50 – 27), of Titanium Pigments (D 186 – 29), of Dry Cuprous Oxide (D 283 – 29), of Dry Mercuric Oxide (D 284 – 29), of White Pigments (D 34 – 30) and Test for Hygroscopic Moisture (and Other Matter Volatile Under the Test Conditions) in Pigments (D 280 – 31) were approved for reference to letter ballot of the Society for advancement to standard.

The withdrawal of the Standard Specifications for Gum Spirits of Turpentine and Steam-Distilled Wood Turpentine (D 13 – 26) and for Destructively-Distilled Wood Turpentine (D 236 – 27) was approved.

Mr. Allen Rogers, chairman of Committee D-1, then presented a brief summary of the activities of the committee and the plans for the coming year.

A paper entitled "Factors in the Presentation and Comparison of Particle Size Data," by E. J. Dunn, Jr. was presented by the author.

The report of Committee D-17 on Naval Stores was presented by P. H. Walker.

The report of Committee D-11 on Rubber Products was presented by the chairman, H. A. Depew. The withdrawal of the Standard Specifications for Wrapped Air Hose for Use with Pneumatic Tools (D 46 – 24), for Braided Air Hose for Use with Pneumatic Tools (D 60 – 24), for Wrapped Cold Water Hose (D 177 – 24) and of the Tentative Specifications for Steam Hose (D 54 – 31 T) was approved. It was announced that these standards which were being discontinued would be replaced by Tentative Methods for Testing Wrapped Hose[1] and for Testing Braided Hose[1] which would be submitted to the Society through Committee E-10 on Standards during the summer. It was also announced that the committee had completed proposed Tentative Methods of Testing Rubber Belting Used for Power Transmission[1] and also revisions in the two existing Tentative Specifications for Insulated Wire and Cable[2] which would likewise be referred to Committee E-10.

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[1] The methods have been issued as tentative, see pp. 915, 909; also Editorial Note, p. 411.

Mr. Arthur W. Carpenter then assumed the chair.

The report of Committee D-13 on Textile Materials was presented by the chairman, H. J. Ball. The proposed Tentative Specifications for Holland Cloth, for Asbestos Roving, and Methods of Test for Small Amounts of Copper and Manganese in Textiles were accepted for publication as tentative.

The revisions proposed for immediate adoption in the Standard Specifications for Tolerances and Test Methods for Tire Fabrics Other than Cord Fabrics (D 122 – 30), for Tire Cord, Woven and on Cones (D 179 – 30), for Hose Ducks and Belt Ducks (D 181 – 25), for Cotton Yarns, Single and Plied (D 180 – 27), for Electrical Cotton Yarns (D 203 – 25) and for Cotton Sewing Threads (D 204 – 27) were unanimously approved for reference to letter ballot of the Society for adoption as standard, this recommendation requiring a nine-tenths vote. The proposed revisions of the Standard General Methods of Testing Woven Textile Fabrics (D 39 – 27), Specifications for Tolerances and Test Methods for Certain Light and Medium Cotton Fabrics (D 274 – 29) and Specifications for Tolerances for Hose Ducks and Belt Ducks (D 181 – 25) were accepted for publication as tentative. The proposed revisions of the Tentative Methods for Identification of Textile Fibers and Their Quantitative Determination in Mixed Goods (D 276 – 31 T) and Definitions of Terms Relating to Textile Materials (D 123 – 30 T) were accepted, the methods and definitions as revised being continued as tentative.

The Tentative Specifications for Tolerances and Test Methods for Knit Goods (D 231 – 28 T), as revised, Specifications and Tests for Cuban (Jute) Raw Sugar Bags (D 275 – 27 T), Specifications and Test Methods for Asbestos Tape for Electrical Purposes (D 315 – 31 T), Specifications for Chafer Tire Fabrics (D 316 – 31 T) and for Enameling Duck for the Tire Industry (D 336 – 31 T) were approved for reference to letter ballot of the Society for adoption as standards.

The tentative revisions of the Standard Specifications for Textile Testing Machines (D 76 – 27), Specifications for Tolerances and Test Methods for Cotton Sewing Threads (D 204 – 27) and for Asbestos Yarns (D 299 – 29) were approved for reference to letter ballot of the Society for advancement to standard. The withdrawal of the Standard Definitions of Terms Relating to Textile Materials (D 123 – 30) was approved. It was announced that the committee had intended that the Standard Specifications for Tolerances and Test Methods for Electrical Silk and Cotton Tapes (D 259 – 27) be withdrawn in 1931 when a revision in the form of separate tentative specifications was issued. The withdrawal of the standard specifications was accordingly approved.

The report of Committee D-9 on Electrical Insulating Materials was presented by the chairman, H. L. Curtis. The proposed Tentative Specifications for Flexible Varnished Tubing Used in Electrical Insulation, for Black Bias-Cut Varnished Cloth Tape Used for Electrical Insulation, and Methods of Testing Sheet and Tape Electrical Insulation for Thickness were accepted for publication as tentative. The proposed revision of the Standard Methods of Testing Electrical Porcelain (D 116 - 30) was accepted for publication as tentative.

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[1] The methods have been issued as tentative, see p. 904; also Editorial Note, p. 411.

[2] The revised specifications appear on pp. 871 and 894, see Editorial Note, p. 411.

The proposed revisions of the Tentative Methods of Testing Sheet and Tape Insulating Materials for Dielectric Strength (D 149 - 32 T), Testing Compounds Used for Splicing Electrical Cables and Filling Potheads (D 176 - 29 T), Testing Untreated Paper Used for Electrical Insulation (D 202 - 32 T), Testing Varnished Cloths and Varnished Cloth Tapes Used in Electrical Insulation (D 295 - 32 T) and Methods of Grading Natural Mica According to Size, Commercial Quality, and Thickness (D 351 - 32 T) were accepted, the methods as revised being continued as tentative.

The Tentative Methods of Test for Resistivity of Electrical Insulating Materials (D 257 - 32 T) were approved for reference to letter ballot of the Society for adoption as standard. The tentative revisions of the Standard Methods of Testing Molded Materials Used for Electrical Insulation (D 48 - 30) and Methods of Testing Electrical Insulating Oils (D 117 - 31) were approved for reference to letter ballot of the Society for advancement to standard.

An informal report of Committee D-15 on Thermometers and Laboratory Glassware was presented by the chairman, W. H. Fulweiler.

The report of Committee D-7 on Timber was presented by the chairman, Hermann von Schrenk. The revisions proposed for immediate adoption in the Standard Specifications for Structural Wood Joist and Planks, Beams and Stringers, and Posts and Timbers (D 245 - 30), Methods of Sampling and Analysis of Creosote Oil (D 38 - 30) and Test for Distillation of Creosote Oil (D 246 - 30) were unanimously approved for reference to letter ballot of the Society for adoption as standard, this recommendation requiring a nine-tenths vote. The Tentative Method for the Determination of the Specific Gravity, 38/15.5 C., of Creosote Fractions (D 38 - 30 T), as revised, and the Tentative Volume and Specific Gravity Correction Tables for Creosote, Creosote Coal-Tar Solution (up to 50 per cent Tar) and Coal Tar (Coke-Oven Tars) (D 347 - 32 T) were approved for reference to letter ballot of the Society for adoption as standards. With the exception of the definition for water-gas tar which will be continued as tentative, the Tentative Definitions of Terms Relating to Timber Preservatives (D 324 - 30 T) were approved for reference to letter ballot of the Society for adoption as standard with the following modification in the definition for coal tar subject to favorable letter ballot of Committee D-7:[1]

Change the definition for coal tar from its present form: namely,

> *Tar, Coal.*—The nonaqueous portion of the liquid distillate obtained during the carbonization of bituminous coal.

to read as follows:

> *Coal Tar.*—Tar produced by the destructive distillation of bituminous coal.

In presenting the report, Mr. von Schrenk called on S. R. Church to present the report of Subcommittee VI on Timber Preservatives.

The meeting then adjourned till 8 p. m.

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[1] The revision was submitted to letter ballot of Committee D-7 which consists of 23 members; 21 members returned their ballots of whom 19 have voted affirmatively and none negatively.

FOURTH SESSION—MONDAY, JUNE 26, 8 P. M.

Presidential Address, Award of Dudley Medal, Reports of Administrative Committees

Past-President K. G. Mackenzie in the chair.

The minutes of the Thirty-fifth Annual Meeting were approved as printed in the 1932 *Proceedings.*[1]

The report of Committee E-6 on Papers and Publications was presented from manuscript by the Assistant Secretary.

The report of Committee E-8 on Nomenclature and Definitions was presented by the secretary, R. E. Hess. This report announced the formulation of definitions for net calorific value and gross calorific value and for coke which were being published as information. The report also called attention to certain definitions that are being recommended by the standing committees for adoption as standard.

An informal progress report of Committee E-9 on Research was presented by the chairman, H. F. Moore.

The report of Committee E-10 on Standards was presented from manuscript by the chairman, T. R. Lawson.

The report of the Executive Committee was presented by the Secretary-Treasurer, C. L. Warwick. The report discussed membership, finances, regional and district committee meetings, activities of numerous standing committees, publications, publicity and promotional activities, and administrative matters concerning relations with other societies and international relations on various standardization projects. A revision of Section 1, Article VI of the By-laws providing for an enlargement of the scope of Committee E-10 on Standards to include the power of approving for publication as tentative proposed revisions of existing standards, recommended by the Executive Committee, was approved for reference to letter ballot of the Society for adoption.

The chairman presented President Cloyd M. Chapman who delivered the annual Presidential Address entitled "Introspection." In his address, President Chapman likened the Society to a standardization machine and proposed a study of its complex nature for the purpose of improving the machine and its products and increasing its efficiency. In considering the origin of its mechanism he pointed out that it came into being by a slow and gradual process of evolution to meet a definite need for knowledge of engineering materials and their standardization. He considered its present development from several viewpoints, and urged careful and thoughtful study of this intelligent and truly automatic machine in order to improve it to the highest degree of perfection.

The chairman then recognized J. B. Young, chairman of the Committee on Award of the Charles B. Dudley Medal. Mr. Young presented Mr. Samuel Epstein, as the recipient of the 1933 Award of the Dudley Medal for his paper on "Embrittlement of Hot-Galvanized Structural Steel," presented at the 1932 annual meeting of the Society, and considered by the committee as a paper of outstanding merit constituting an original contribution on research in materials.

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[1] *Proceedings,* Am. Soc. Testing Mats., Vol. 32, Part I, p. 13 (1932).

On behalf of and as the representative of the Society, President Chapman then made the Seventh Award of the Charles B. Dudley Medal to Mr. Epstein.

In accepting the medal Mr. Epstein expressed his appreciation of the award as follows:

> "Last June in presenting the paper which has now been awarded this medal I said how much I had enjoyed doing the work. One of the things I liked most about it was meeting the members of Subcommittee X on Embrittlement Investigation of Committee A-5 on Corrosion of Iron and Steel. We all must have faith and loyalty in our profession, and I can say that the devotion and efficiency I saw in the committee's conduct of its job taught me something which I highly cherish. Because of the diverse membership of the committee, conflicting viewpoints would naturally arise, and I recall how sometimes the chairman, Mr. V. F. Hammel would say, 'Now fellows, remember we are doing this for the A.S.T.M.' That remark would always have the desired effect, and an agreement would be reached. So many, nowadays, have grown to doubt the value of democratic forms, of which the committee is such an important one. I like to think, therefore, with all due modesty, that this work, carried on under the leadership of a committee, proved deserving of a medal.
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> "In research no one goes alone. There are things in the embrittlement paper, gathered from sources from every part of the world, without which it would not be complete. We have come to expect such aid. However, we cannot always be so fortunate as to have the associations and help I had in this work. It gives me pleasure to mention the names of the Steering Committee of Subcommittee X of Committee A-5: V. F. Hammel, J. J. Shuman, H. O. Hill, E. F. Kelley, C. F. W. Rys and C. S. Trewin. I would also like to mention the help of C. L. Warwick and his staff in editing the paper. It would be an inspiration to any author to see how carefully and sympathetically his paper is edited in the A.S.T.M. offices. Finally it gives me the greatest pleasure to acknowledge the aid and encouragement I received from Dr. H. W. Gillett and Dr. O. E. Harder at Battelle Memorial Institute and the faithful and efficient assistance of Mr. Daniloff and Mr. Motok."

The chairman then recognized H. G. Farmer, chairman of the Committee of Tellers, who reported the results of the letter ballot on election of officers. Of the 820 ballots cast the results were as follows:

For President, to serve for one year: T. R. Lawson, 820 votes.

For Vice-President, to serve for two years: Hermann von Schrenk, 820 votes.

For Members of Executive Committee, to serve for two years:

F. A. Barbour, 820 votes.
A. C. Fieldner, 820 votes.
C. N. Forrest, 820 votes.
J. C. Pearson, 820 votes.
A. E. White, 820 votes.

The President-Elect T. R. Lawson was then escorted to the chair by Past-Presidents H. F. Moore and F. O. Clements.

The chairman then recognized Past-President W. H. Fulweiler and Vice-President W. H. Bassett, who escorted the Vice-President-Elect Hermann von Schrenk to the chair.

The chairman then introduced the newly elected members of the Executive Committee.

The meeting then adjourned till the following morning and was followed by an informal reception to the new officers and members of the Executive Committee.

FIFTH SESSION—TUESDAY, JUNE 27, 9.30 A. M.

Steel, Wrought Iron

(Held Simultaneously with Sixth Session)

Past-President J. A. Capp in the chair.

The report of Committee A-4 on Heat Treatment of Iron and Steel was presented by the chair. The tentative revisions of the terms heat treatment, annealing, normalizing and tempering appearing in the Standard Definitions of Terms Relating to Heat Treatment Operations (Especially as Related to Ferrous Alloys) (A 119 – 30) and a definition of the term nitriding were approved for reference to letter ballot of the Society for advancement to standard.

The report of Committee A-6 on Magnetic Properties was presented by the chairman, Thomas Spooner. The tentative revision of the Standard Methods of Test for Magnetic Properties of Iron and Steel (A 34 – 28) in the form of separate tentative methods was approved for reference to letter ballot of the Society for advancement to standard with the following modifications in the tentative methods, presented on the floor of the meeting, subject to approval by letter ballot of Committee A-6:[1]

Section 1 (g).—Change the first sentence of the definition for Standard Core Loss to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

> The total power in watts consumed in each kilogram of material at a temperature of 25 C ± *5 C.* when subjected to an alternating magnetizing force so as to produce [a variable] *an* induction varying harmonically between specified limits of + B and − B and of frequency f.

Section 2 (d).—Change this section from its present form to read as follows:

> (*d*) Test specimens of sheet material in the form of straight strips shall be cut one-half parallel and the other half at right angles to the direction of rolling, and in types of test requiring companion samples, each half shall contain an equal number of each kind of strips. When the material is to be used with the flux at approximately 45 deg. with reference to the direction of rolling of the sheets, it is permissible by agreement between the manufacturer and customer to make permeability tests of strips cut on an angle of 45 deg. to the direction of rolling. (Only one type of strip will then be necessary for such tests.)

Section 6.—Change to read as follows by the addition of the italicized words and figures:

> The tests may be made by means of one of the following methods, ***provided the temperature of the sample is maintained between 20 and 30 C.***

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[1] The proposed revisions were submitted to letter ballot of Committee A-6 which consists of 16 members; 15 members returned their ballots, all of whom voted affirmatively.

Add to Paragraph (*d*) the following as a second paragraph:

> *Modified Isthmus Method.*—This method as described in U. S. Bureau of Standards *Journal of Research*, Vol. 10, p. 567 (1933) is suitable for tests at magnetizing forces from 100 to 1000 oersteds. If higher values of magnetizing forces are required the Isthmus method as described in the preceding paragraph may be used.

Section 8.—Replace Paragraph (*a*) of this section, which describes the test specimen, by the following:

> 8. (*a*) Test specimens shall consist of 10 kg. (22 lb.) of strips 50 cm. ($19\frac{11}{16}$ in.) in length and 3 cm. ($1\frac{3}{16}$ in.) in width cut with sharp shears from two or more sheets taken at random from shipment. It is recommended that a test specimen shall represent not more than 5000 kg. (11,000 lb.). The strips shall be cut symmetrically from the sheet as nearly as may be practicable. (See Figs. 1 and 2).

Section 14.—Change the next to the last sentence to read as follows by the addition of the italicized words and the omission of those in brackets:

> The four groups shall then be assembled in the test coils to form a square with the corners so arranged that [at each corner consecutive layers mutually overlap the butt joints occurring in each single layer] *the layers alternately butt and lap.*

Section 17 (*c*).—Change Paragraph (*c*) from its present form to read as follows:

> (*c*) The adjustable condenser, C_4, shall be a 3 decade condenser having steps of $9 \times (0.1 + 0.01 + 0.001)$ microfarads adjusted to an accuracy of ± (0.025 per cent + 50 micro-microfarads), and having a power factor of not more than 0.0015 at 1000 cycles per second. In addition C_4 shall include a single 1 microfarad mica condenser of the same accuracy, with suitable means for inserting it in the circuit.

The report of Committee A-2 on Wrought Iron was presented by the vice-chairman, James Aston. The proposed Tentative Specifications for Wrought-Iron Rivets and Rivet Rounds were accepted for publication as tentative. Revisions proposed for immediate adoption in the Standard Specifications for Welded Wrought-Iron Pipe (A 72 – 31), for Staybolt, Engine-Bolt and Extra-Refined Wrought-Iron Bars (A 84 – 30) and in the definition of the term muck bar, appearing in the Standard Definitions of Terms Relating to Wrought Iron Specifications (A 81 – 30), were unanimously approved for reference to letter ballot of the Society for adoption as standard, this recommendation requiring a nine-tenths vote. The tentative revisions of the Standard Specifications for Staybolt, Engine-Bolt and Extra-Refined Wrought-Iron Bars (A 84 – 30) and the revised definition of the term double-refined iron, appearing in the Standard Definitions of Terms Relating to Wrought Iron Specifications (A 81 – 30), were approved for reference to letter ballot of the Society for advancement to standard.

The report of Committee A-1 on Steel was presented by the chairman, H. H. Morgan. The proposed Tentative Specifications for Heat-Treated Steel Elliptical Springs for Railway Equipment were accepted for publication as tentative. The proposed Tentative Specifications for Alloy-Steel Castings for Structural Purposes were accepted for publication as tentative with the following modifications subject to favorable letter ballot of Committee A-1:[1]

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[1] The proposed revisions were submitted to letter ballot of Committee A-1 which consists of 186 members; 121 members returned their ballots of whom 82 voted affirmatively and none negatively.

Section 3 (a).—Change the last sentence to read as follows by the addition of the italicized words:

> The castings shall not be removed from the furnace until the pyrometer shows that the furnace *charge* has fallen *uniformly* to a temperature as low as 500 F. (260 C.).

Section 7.—Delete the last sentence which reads as follows in the specifications as preprinted:

> The phosphorus and sulfur content thus determined shall not exceed that specified in Section 5 (*a*) by more than 20 per cent.

The proposed Tentative Specifications for Lap-Welded and Seamless Steel Pipe for High-Temperature Service were accepted for publication as tentative to supersede the present Standard Specifications A 106 – 29, with the following modifications in the specifications as preprinted subject to favorable letter ballot of Committee A-1:[1]

Section 5 (a).—Change the minimum tensile strength requirement of Grade B seamless pipe from "60,000 lb. per sq. in." to "62,000 lb. per sq. in."

It was announced that a revised table of dimensions and weights covering Grade A pipe, prepared by the Sectional Committee on Standardization of Dimensions and Material of Wrought-Iron and Wrought-Steel Pipe and Tubing, would, when completed, be incorporated in the new tentative specifications.

The committee presented on the floor of the annual meeting proposed Tentative Specifications for High Tensile Strength Carbon-Steel Plates for Pressure Vessels (Plates 2 in. and Under in Thickness) and Specifications for High Tensile Strength Carbon-Steel Plates for Fusion Welded Pressure Vessels (Over 2 in. up to and Including 4 in. in Thickness) which specifications had not been included in the report of the committee as preprinted. The specifications were accepted for publication as tentative subject to favorable letter ballot of Committee A-1.[2]

The revisions proposed for immediate adoption in the Standard Specifications for Structural Steel for Bridges (A 7 – 29) and for Structural Steel for Buildings (A 9 – 29), with the following modification subject to favorable letter ballot of Committee A-1,[3] were unanimously approved for reference to letter ballot of the Society for adoption as standard, this recommendation requiring a nine-tenths vote:

New Section.—Change the paragraph proposed as a new Section 2 to read as follows by the addition of the italicized words:

> 2. Rolled Base Plates.—Rolled base plates *over 2 in. in thickness* for bearing purposes, shall be open-hearth or electric-furnace steel containing 0.15 to 0.30 per cent carbon. Other chemical properties shall conform to the requirements specified in Section 4. Sufficient discard shall be made from the top of each ingot to secure sound plates. Physical tests shall not be required for this material.

The revisions proposed for immediate adoption in the Standard Specifications for Welded and Seamless Steel Pipe (A 53 – 30), for Boiler and Firebox Steel for Locomotives (A 30 – 24), for Boiler and Firebox Steel for Stationary Service (A 70 – 27), for Commercial Quality Hot-Rolled Bar Steels (A 107 – 30), for Commercial Cold-Finished Bar Steels and Cold-Finished Shafting (A 108 –

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[1] The proposed revisions were submitted to letter ballot of Committee A-1 which consists of 186 members; 121 members returned their ballots of whom 77 voted affirmatively and none negatively.

[2] The proposed tentative specifications were submitted to letter ballot of Committee A-1 which consists of 186 members; 121 members returned their ballots of whom 72 voted affirmatively and none negatively.

[3] The revision as modified was submitted to letter ballot of Committee A-1 which consists of 186 members; 121 members returned their ballots of whom 74 voted affirmatively and none negatively.

30), for Steel Plates of Structural Quality for Forge Welding (A 78 – 30), for Carbon-Steel Castings for Valves, Flanges and Fittings for High-Temperature Service (A 95 – 29), for Alloy-Steel Bolting Material for High-Temperature Service (A 96 – 31) and for Forged or Rolled Steel Pipe Flanges for High-Temperature Service (A 105 – 28) were unanimously approved for reference to letter ballot of the Society for adoption as standard, this recommendation requiring a nine-tenths vote.

The proposed revision of the Standard Specifications for Cold-Drawn Steel Wire for Concrete Reinforcement (A 82 – 27) was accepted for publication as tentative. The proposed revision of the Tentative Specifications for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83 – 32 T), which specifications are being advanced to standard, was accepted for publication as tentative with the following modification subject to favorable letter ballot of Committee A-1:[1]

Marking Clause.—Change the proposed revision of Section 17 in the report as preprinted from its present form: namely,

> 17. (*a*) Except as specified in Paragraph (*b*), the name or brand of the manufacturer, the grade of material from which it is made, whether lap-welded steel or iron, and the hydrostatic pressure in pounds at which it was tested shall be legibly stenciled on each tube.
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> (*b*) When tubes under 1½ in. in outside diameter are in 3 ft. and shorter lengths they may be bundled, and the marking specified in Paragraph (*a*) legibly stamped on a metal tag securely attached to each bundle.

to read as follows:

> 17. (*a*) The name or brand of the manufacturer, the grade of material from which it is made, whether seamless or lap-welded, and whether steel or iron, together with the hydrostatic pressure in pounds at which it was tested, shall be legibly stenciled on each tube 1¼ in. in outside diameter and over, provided the length is not under 3 ft.
>
> (*b*) On tubes less than 1¼ in. in diameter and on all tubes under 3 ft. in length, the name or initials or brand of the manufacturer shall be legibly stenciled or indicated on a sticker applied on each tube.

The proposed revision of the Tentative Specifications for Normalized and Tempered Alloy-Steel Forgings for Locomotives (A 133 – 31 T) was accepted, the specifications as revised being continued as tentative.

The proposed revision of the Tentative Specifications for Structural Medium-Steel (A 140 – 32 T), with the following modification subject to favorable letter ballot of Committee A-1,[2] was accepted, the specifications as revised being continued as tentative:

New Section.—Change the paragraph proposed as a new Section 2 to read as follows by the addition of the italicized words:

> 2. Rolled Base Plates.—Rolled base plates *over 2 in. in thickness* for bearing purposes shall be open-hearth or electric-furnace steel containing 0.20 to 0.35 per cent carbon. Other chemical properties shall conform to the requirements specified in Section 4. Sufficient discard shall be made from the top of each ingot to secure sound plates. Physical tests shall not be required for this material.

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[1] The revision as modified was submitted to letter ballot of Committee A-1 which consists of 186 members; 121 members returned their ballots of whom 73 voted affirmatively and 1 negatively.

[2] The revision as modified was submitted to letter ballot of Committee A-1 which consists of 186 members; 121 members returned their ballots of whom 74 voted affirmatively and none negatively.

The Tentative Specifications for Soft Steel Track Spikes (A 65 – 32 T), for Structural Rivet Steel (A 141 – 32 T), for Marine Boiler Steel Plates (A 114 – 29 T), for Heat-Treated Carbon-Steel Helical Springs (A 125 – 31 T), for Austenitic Manganese-Steel Castings (A 128 – 30 T) and for Open-Hearth Iron Plates of Flange Quality (A 129 – 30 T) were approved for reference to letter ballot of the Society for adoption as standards. The Tentative Specifications for Structural Steel for Ships (A 131 – 31 T), to supersede the Standard Specifications for Structural Steel for Ships (A 12 – 21) and for Rivet Steel for Ships (A 13 – 24); and the Tentative Specifications for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83 – 32 T), to supersede the present Standard Specifications A 83 – 30, were approved for reference to letter ballot of the Society for adoption as standards.

The Tentative Specifications for Steel Plates of Flange and Firebox Qualities for Forge Welding (A 89 – 32 T), to supersede the present Standard Specifications A 89 – 30, were approved for reference to letter ballot of the Society for adoption as standard with the following modification in the homogeneity test clause subject to favorable letter ballot of Committee A-1:[1]

Section 9.—Change this section from its present form to read as follows:

> 9. (*a*) The object of the homogeneity test, which is required for firebox steel only, is to open and render visible to the eye any seams due to failure to weld up or to interposed foreign matter, or any cavities due to gas bubbles in the ingot. The fractured surface of the test specimen shall not show any single seam or cavity more than ¼ in. in length for plates ¾ in. and under in thickness, more than ⅜ in. in length for plates over ¾ to 4 in., inclusive, nor more than ½ in. in length for plates over 4 to 6 in., inclusive, in any of the fractures obtained in accordance with Paragraph (*b*). One side of each fracture shall be examined and the lengths of the seams and cavities determined, a pocket lens being used if necessary.
>
> (*b*) The test may be made on a broken tension test specimen when an 8-in. gage length specimen is used. When a 2-in. gage length tension test specimen is used, the specimen for homogeneity test shall be taken adjacent, sidewise or lengthwise, to the top tension test specimen. For plates ¾ in. and under in thickness the specimen shall be nicked or grooved transversely, in three places, about $\frac{1}{16}$ in. deep. The first groove shall be 2 in. from the square end, and each succeeding groove on the opposite side about 2 in. from the preceding one. The specimen shall be broken at each groove in succession with a hammer or press, the bending being away from the groove. For plates over ¾ in. and up to 2⅛ in., inclusive, in thickness the specimen may be grooved about ⅛ in. deep, at one place on one side. For plates over 2⅛ in. in thickness the specimen may be grooved at one place on both sides to leave a fracture which will include the horizontal axis of the plate and have a face at least 2 in. in depth.

The tentative revisions of the Standard Specifications for Low-Carbon-Steel Splice Bars (A 3 – 24), for Quenched Carbon-Steel Track Bolts (A 50 – 24), for Quenched Alloy-Steel Track Bolts (A 51 – 21), for Steel Screw Spikes (A 66 – 21), for Low-Carbon-Steel Track Bolts (A 76 – 27), for Steel Tie Plates (A 67 – 30), for Structural Steel for Buildings (A 9 – 29), for Structural Silicon Steel (A 94 – 29), for Cold-Drawn Steel Wire for Concrete Reinforcement

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[1] The proposed revision was submitted to letter ballot of Committee A-1 which consists of 186 members; 121 members returned their ballots of whom 74 voted affirmatively and none negatively.

(A 82 – 27), for Welded and Seamless Steel Pipe (A 53 – 30), for Commercial Quality Hot-Rolled Bar Steels (A 107 – 30) and for Commercial Cold-Finished Bar Steels and Cold-Finished Shafting (A 108 – 30) were approved for reference to letter ballot of the Society for advancement to standard.

The tentative revisions in Sections 3, 10 and 11 (*a*) and the new Section 15 of the Standard Specifications for Billet-Steel Concrete Reinforcement Bars (A 15 – 30), and in Sections 2, 6 and 7 (*a*) of the Standard Specifications for Rail-Steel Concrete Reinforcement Bars (A 16 – 14) were approved for reference to letter ballot of the Society for advancement to standard. The following revision, not included in the report of the committee as preprinted, in Section 13 of Standard Specifications A 15 and in Section 9 of Specifications A 16 was presented on the floor of the annual meeting and unanimously approved for reference to letter ballot of the Society for immediate adoption as standard subject to favorable letter ballot of Committee A-1:[1]

Permissible Variations in Weight.—Change Section 13 of Standard Specifications A 15 and Section 9 of Specifications A 16 from their present form: namely,

> The weight of any lot of bars shall not vary more than 5 per cent from the theoretical weight of that lot.

to read as follows:

> The weight of any lot of bars shall not vary more than 3½ per cent over or under the theoretical weight for bars ⅜ in. and over in diameter nor more than 5 per cent over or under for bars under ⅜ in. in diameter. The theoretical weight of deformed bars shall be the theoretical weight of plain round or square bars of the same nominal size. The term "lot" used in this paragraph means all the bars of the same nominal weight per linear foot in a carload.

The withdrawal of the Standard Specifications for Cold-Rolled Steel Axles (A 22 – 21) and for Lap-Welded and Seamless Steel Pipe for High-Temperature Service (A 106 – 29) was approved.

The List of Specifications for Steel Suitable for Fusion Welding was approved for publication in the Book of A.S.T.M. Standards.

The report of the Sectional Committee on Standardization of Dimensions and Material of Wrought-Iron and Wrought-Steel Pipe and Tubing was presented by the chairman, H. H. Morgan.

Mr. E. F. Kenney then assumed the chair.

A paper entitled "Shearing Properties and Poisson's Ratio of Structural and Alloy Steels," by Inge Lyse and H. J. Godfrey was presented by Mr. Godfrey and discussed.

A paper entitled "The Torsion Impact Test," by G. V. Luerssen and O. V. Greene was presented by Mr. Greene and discussed.

An informal report of the Joint Committee on Investigation of the Effect of Phosphorus and Sulfur in Steel was presented by the acting chairman, H. S. Rawdon.

The meeting then adjourned till 3.30 p. m.

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[1] The proposed revision was submitted to letter ballot of Committee A-1 which consists of 186 members; 121 members returned their ballots of whom 70 voted affirmatively and 1 negatively.

SIXTH SESSION—TUESDAY, JUNE 27, 9.30 A. M.

Ceramics, Refractories, Masonry Materials

(Held Simultaneously with Fifth Session)

Vice-President T. R. Lawson in the chair.

The progress report of Committee C-4 on Clay Pipe was presented by the chairman, G. T. Hammond. The withdrawal of the Standard Specifications for Clay Sewer Pipe (C 13 - 24) recommended on the floor at the annual meeting was unanimously approved subject to favorable letter ballot of Committee C-4.[1] It was announced that the committee had completed revisions of the Tentative Specifications for Clay Sewer Pipe (C 13 - 32 T)[2] and proposed tentative revisions of the Recommended Practice for Laying Sewer Pipe (C 12 - 19) and Standard Definitions of Terms Relating to Sewer Pipe (C 8 - 24), which would be presented to the Society during the summer through Committee E-10 on Standards.

The report of Committee C-8 on Refractories was presented by E. H. van Schoick. The proposed Tentative Methods of Testing High-Temperature Heat Insulation (Compression, Flexure, Shrinkage) were accepted for publication as tentative. The revisions proposed for immediate adoption in the Standard Methods of Test for Porosity and Permanent Volume Changes in Refractory Materials (C 20 - 20) and for Softening Point of Fire-Clay Brick (C 24 - 31), were unanimously approved for reference to letter ballot of the Society for adoption as standard, this recommendation requiring a nine-tenths vote. The proposed revision of the Standard Method of Test for Refractory Materials Under Load at High Temperatures (C 16 - 20) was accepted for publication as tentative. The recommendation that the term "softening point" be changed to read "pyrometric cone equivalent," also the term "Orton Cones" changed to read "Standard Pyrometric Cones" in all of the standards under the jurisdiction of Committee C-8 in which they appear, was accepted for publication as a tentative revision. The proposed revision of the Tentative Method of Control Test for Resistance of Fire-Clay Brick to Thermal Spalling Action (C 38 - 31 T) was accepted, the method as revised being continued as tentative. The advancement to standard of the tentative revisions of the Standard Methods of Test for Porosity and Permanent Volume Changes in Refractory Materials (C 20 - 20) and for Softening Point of Fire-Clay Brick (C 24 - 31) were approved for reference to letter ballot of the Society for adoption.

A paper entitled "Strength, Water Absorption and Weather Resistance of Building Bricks Produced in the United States," by J. W. McBurney and C. E. Lovewell was presented from manuscript by Mr. McBurney and discussed.

A paper entitled "Tests on Brick Masonry Beams," by M. O. Withey was presented by the author and discussed.

Mr. G. C. D. Lenth then assumed the chair.

The report of Committee C-10 on Hollow Masonry Building Units was presented by the chairman, D. E. Parsons. The proposed revisions of the Standard Specifications and Tests for Structural Clay Load-Bearing Wall Tile (C 34 - 31), for Structural Clay Fireproofing, Partition and Furring Tile

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[1] The recommendation to withdraw the specifications was submitted to letter ballot of Committee C-4 which consists of 18 members; 15 members returned their ballots all of whom voted affirmatively.

[2] The revised specifications appear on p. 691.

(C 56 - 31), for Structural Clay Floor Tile (C 57 - 31), and Definitions of Terms Relating to Structural Clay Tile (C 43 - 31), in the form of separate tentative standards, were presented with additional modifications in the specifications as preprinted comprising a change in classification of tile from "6 - 16" to "5 - 16," a reduction in the individual minimum absorption requirement from 5 per cent to 4 per cent, and a revision of the section covering scoring of tile. The title of the Specifications for Structural Clay Fireproofing, Partition and Furring Tile was changed to read "Specifications for Structural Clay Non-Load-Bearing Tile," and requirements were added to these specifications covering split furring tile. The definition of structural clay tile was also changed to read as follows: "*Structural Clay Tile.*—Hollow burned clay masonry building units with parallel cells." The proposed revisions in the form of separate tentative standards were accepted for publication as tentative as amended, subject to favorable letter ballot of Committee C-10.[1]

An informal progress report of Committee C-12 on Mortars for Unit Masonry was presented by the chairman, R. E. Davis.

A paper entitled "Permeability of Brick Masonry Walls—An Hypothesis" by W. C. Voss was presented by the author and discussed.

The meeting then adjourned till 3.30 p. m.

SEVENTH SESSION—TUESDAY, JUNE 27, 3.30 P. M.

Edgar Marburg Lecture

(Joint Session with Section M (Engineering) of the American Association for the Advancement of Science)

President Cloyd M. Chapman in the chair.

The President in opening the session extended a hearty welcome to the members of the American Association for the Advancement of Science at this session arranged jointly under the auspices of both societies. President Chapman then briefly recounted the purpose and significance of the Edgar Marburg Lecture which annually commemorates the first Secretary-Treasurer of the Society and also brings to the Society valuable expositions on notable developments in engineering and the sciences. President Chapman paid tribute to the initiative and foresight of Edgar Marburg in laying a firm foundation for the Society which contributed greatly in furthering the knowledge of engineering materials through the investigative and research committee work and the presentation of technical papers describing tests for and studies of the properties of materials.

In introducing the eighth Edgar Marburg Lecturer, President Chapman called attention to the fact that we were particularly fortunate in hearing from an eminent English scientist, a Fellow of the Royal Society and one who had made many notable achievements in his chosen field of endeavor in the engineering world. He then presented Dr. Herbert John Gough, F.R.S., Superintendent of the Engineering Division, British National Physical Laboratory, who chose as the subject of the lecture: "Crystalline Structure in Relation to Failure of Metals, Especially by Fatigue." In the course of his lecture Doctor Gough unfolded a number of interesting conclusions that he had drawn as the result of his studies over a period of some ten years in the field of research on the fatigue of metals. His lecture, which was illustrated by many photomicrographs of metals, constitutes a very important fundamental summary of our present-day knowledge of the nature of solid bodies.

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[1] The revisions as modified were submitted to letter ballot of Committee C-10 which consists of 34 members; 23 members returned their ballots with the following results: Specifications C 34, 20 affirmative, 2 negative; Specifications C 56, 20 affirmative, 2 negative; Specifications C 57, 20 affirmative, 0 negative; Definitions C 43, 22 affirmative and 0 negative.

The lecture was then discussed by Zay Jeffries and H. F. Moore.

President Chapman in expressing appreciation to Doctor Gough for his fine exposition of a subject of vital interest to the Society presented to him on behalf of the Society the Edgar Marburg Lecture Certificate.

The meeting then adjourned till Thursday morning, Wednesday being set aside for Engineers Day in which the Society participated.

EIGHTH SESSION—THURSDAY, JUNE 29, 9.30 A. M.

Fatigue of Metals, Testing, Metallography

(Held Simultaneously with Ninth Session)

Dr. Herbert John Gough, F.R.S., in the chair.

The report of Committee E-1 on Methods of Testing was presented by the chairman, W. H. Fulweiler. The proposed Tentative Methods of Verification of Testing Machines, and of Analysis for the Particle Size Distribution of Sub-Sieve Size Particulate Substances were accepted for publication as tentative.

The proposed revision of the Tentative Methods of Compression Testing of Metallic Materials (E 9 – 27 T) was accepted, the method as revised being continued as tentative. The Tentative Methods of Tension Testing of Metallic Materials (E 8 – 32 T) and Specifications for Round-Hole Screens for Testing Purposes (E 17 – 31 T) were approved for reference to letter ballot of the Society for adoption as standards. The withdrawal of the Standard Methods of Verification of Testing Machines (E 4 – 27) was approved.

In presenting the report Mr. Fulweiler called on H. F. Moore to describe the activities of the Technical Committee on Mechanical Testing and on H. F. Dodge to present from manuscript the Manual on Presentation of Data prepared by the Technical Committee on Presentation of Data.

The report of Committee E-4 on Metallography was presented by the chairman, C. H. Davis. The Tentative Recommended Practice for Thermal Analysis of Steel (E 14 – 30 T) was approved for reference to letter ballot of the Society for adoption. The Tentative Grain Size Chart for Classification of Steels (E 19 – 33 T) was unanimously approved for reference to letter ballot of the Society for immediate adoption as standard, this recommendation requiring a nine-tenths vote.

An informal progress report of the Research Committee on Fatigue of Metals was presented by the chairman, H. F. Moore.

A paper entitled "An 'Overnight' Test for Determining Endurance Limit," by H. F. Moore and H. B. Wishart was presented by Mr. Wishart and discussed.

Past-President H. F. Moore then assumed the chair.

A paper entitled "Fatigue Tests of Galvanized Wire Under Pulsating Tensile Stress," by S. M. Shelton and W. H. Swanger was presented from manuscript by Mr. Swanger and discussed.

A paper entitled "The Fatigue Properties of Light Metals and Alloys," by R. L. Templin was presented by the author and discussed.

A paper entitled "Relative Merits of Film and Paper for Industrial X-ray Work," by Ancel St. John and H. R. Isenburger was presented by Mr. Isenburger.

The report of Committee C-5 on Fire Tests of Materials and Construction was presented by the secretary, Fitzhugh Taylor. The Tentative Specifications for Fire Tests of Building Construction and Materials (C 19 - 26 T), as revised, were approved for reference to letter ballot of the Society for adoption as standard.

The meeting then adjourned till 2 p. m.

NINTH SESSION—THURSDAY, JUNE 29, 9.30 A. M.

Road Materials, Waterproofing Materials, Petroleum Products, Coal and Coke

(Held Simultaneously with Eighth Session)

Mr. C. S. Reeve in the chair.

The report of Committee D-4 on Road and Paving Materials was presented by the chairman, H. F. Clemmer. The proposed Tentative Specifications for Concrete for Pavements were accepted for publication as tentative. The revisions proposed for immediate adoption in the Standard Methods of Test for Abrasion of Rock (D 2 - 26) and for Loss on Heating of Oil and Asphaltic Compounds (D 6 - 30) were unanimously approved for reference to letter ballot of the Society for adoption as standard, this recommendation requiring a nine-tenths vote. The proposed revisions of the Tentative Specifications for Calcium Chloride for Dust Prevention (D 98 - 30 T) and Methods of Testing Bituminous Emulsions (D 244 - 28 T) were accepted, the specifications and methods as revised being continued as tentative.

The following revision of the definition for coal tar, appearing in the Standard Definitions of Terms Relating to Materials for Roads and Pavements (D 8 - 18), presented on the floor at the annual meeting was unanimously approved for reference to letter ballot of the Society for immediate adoption as standard subject to favorable letter ballot of Committee D-4:[1]

Change the definition for coal tar from its present form: namely,

> *Coal Tar.*—The mixture of hydrocarbon distillates, mostly unsaturated ring compounds, produced in the destructive distillation of coal.

to read as follows:

> *Coal Tar.*—Tar produced by the destructive distillation of bituminous coal.

The report of Committee D-8 on Bituminous Waterproofing and Roofing Materials was presented by the chairman, J. M. Weiss. The proposed Tentative Specifications for Asphalt Cap Sheet Surfaced with Mineral Granules were accepted for publication as tentative. The proposed revisions of the Standard Specifications for Asphalt Roll-Roofing Surfaced with Powdered Talc (D 224 - 27), for Asphalt Roll-Roofing and Asphalt Shingles Surfaced with Mineral Granules (D 225 - 29), for Asphalt Roll-Roofing Surfaced with Mineral Talc (D 248 - 27) and for Heavy Weight Asphalt Roll-Roofing and Heavy Weight Asphalt Shingles Surfaced with Mineral Granules (D 249 - 27) were accepted. The committee further proposed the withdrawal as standard of these four specifications and recommended their publication as tentative as revised, which recommendation was accepted subject to approval by Committee D-8.[1]

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[1] The definition as revised was submitted to letter ballot of Committee D-4 which consists of 91 members; 62 members returned their ballots of whom 61 voted affirmatively and 1 negatively.

The proposed revision of the Tentative Methods of Testing Asphalt Roll-Roofing Surfaced with Fine Talc, Granular Talc or Mineral Granules, also Asphalt Shingles Surfaced with Mineral Granules (D 228 - 31 T) was accepted, the methods as revised being continued as tentative.

In presenting the report Mr. Weiss called on O. G. Strieter to present the report of Subcommittee VIII on Accelerated Weathering Tests.

A paper entitled "Method and Apparatus for the Recovery of Asphalt," by Gene Abson was presented by the author and discussed.

A paper entitled "A Qualitative Test for Determining the Degree of Heterogeneity of Asphalts," by G. L. Oliensis was presented by the author and discussed.

Past-President W. H. Fulweiler then assumed the chair.

The report of Committee D-2 on Petroleum Products and Lubricants was presented by the chairman, T. A. Boyd. The revision proposed for immediate adoption in the Standard Method of Test for Sulfur in Petroleum Oils Heavier than Illuminating Oil (D 129 - 27) was unanimously approved for reference to letter ballot of the Society for adoption as standard, this recommendation requiring a nine-tenths vote. The proposed revision of the Tentative Method of Test for Penetration of Greases and Petrolatum (D 217 - 27 T) was accepted, the methods as revised being continued as tentative. The Tentative Methods of Test for Dilution of Crankcase Oils (D 322 - 30 T), for Distillation of Crude Petroleum (D 285 - 30 T), for Gravity of Petroleum and Petroleum Products (D 287 - 32 T), for Precipitation Number of Lubricating Oils (D 91 - 30 T) and Methods of Sampling Petroleum and Petroleum Products (D 270 - 30 T) were approved for reference to letter ballot of the Society for adoption as standards. The tentative revisions of the Standard Methods of Test for Flash and Fire Points by Means of Open Cup (D 92 - 24), Cloud and Pour Points (D 97 - 30) and for Viscosity of Petroleum Products and Lubricants (D 88 - 30) were approved for reference to letter ballot of the Society for advancement to standard. Additional revisions of these two standards were then presented on the floor of the annual meeting, as follows:

Proposed revisions[2] of the Standard Methods D 97, made desirable by the introduction during the past few years of oils containing pour-point depressants, were accepted for publication as tentative subject to favorable letter ballot of Committee D-2.[3]

The following proposed revisions of the Standard Methods D 88, were unanimously approved for reference to letter ballot of the Society for immediate adoption as standard subject to favorable letter ballot of Committee D-2:[4]

Section 2 (*c*).—Add to the tabulation on range and subdivision of thermometers the following requirements covering two new sets of two thermometers, one set graduated in Fahrenheit and the other in Centigrade degrees:

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[1] This recommendation was subsequently approved by Committee D-8.

[2] The revisions appear on pp. 336 and 1041.

[3] The proposed revisions were submitted to letter ballot of Committee D-2 which consists of 101 members; 47 members returned their ballots of whom 39 voted affirmatively and 5 negatively.

[4] The proposed revisions were submitted to letter ballot of Committee D-2 which consists of 101 members; 47 members returned their ballots of whom 46 voted affirmatively and none negatively.

Range 134 — 148 F., subdivision in 0.2 F. for tests at 140 F.
Range 174 — 188 F., subdivision in 0.2 F. for tests at 180 F.

or

Range 57 — 65 C., subdivision in 0.1 C. for tests at 60 C.
Range 79 — 87 C., subdivision in 0.1 C. for tests at 82.2 C.

Section 3 (*b*).—Change this section to read as follows by the addition of the italicized words and figures and the omission of the figures in brackets:

3. (*b*) With the Saybolt Furol Viscosimeter determinations shall be made at 77, *100*, 122 or [212] *210* F. (25, *37.8*, 50 or [100] *98.9* C.) *In tests of road and paving materials, determinations may also be made at 140 and 180 F.* (*60 and 82.2 C.*).

Section 4.—Change the last sentence of the first paragraph of Section 4 to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

In tests at *140, 180 and* 210 [and 212] F. (*60, 82.2 and* 98.9 [and 100] C.) a variation of ±0.2 F. (0.11 C.) is permitted.

Change the first sentence of the second paragraph of Section 4 to read as follows by the addition of the italicized figures and the omission of those in brackets:

Any construction of bath may be employed provided the bath temperature necessary to maintain thermal equilibrium (while the oil in the oil tube is well stirred by the oil tube thermometer) is within ± 0.1 F. (0.06 C.) from the standard temperature of 77 F. (25 C.) or is not in excess of 100.25, 122.35, 130.50, *141.0, 181.5 or* 212 [or 214] F. (37.9, 50.2, 54.7, *60.6, 83.1* and 100 [101.1] C.) respectively, for the other standard temperatures previously mentioned.

The report of Committee D-5 on Coal and Coke was presented by the chairman, A. C. Fieldner. The tentative revision of the Standard Methods of Laboratory Sampling and Analysis of Coal and Coke (D 271 - 30) comprising an alternate procedure of laboratory sampling of coal was approved for reference to letter ballot of the Society for advancement to standard.

A paper entitled "A Study of Adsorption as a Method for the Determination of the Surface of Pulverized Coal," by R. A. Sherman, C. E. Irion and E. J. Rogers was presented by Mr. Sherman and discussed.

A paper entitled "Agglutinating Value Test for Coal," by W. A. Selvig, B. B. Beattie and J. B. Clelland was presented by Mr. Selvig and discussed.

The report of the Sectional Committee on Classification of Coals was presented by the chairman, A. C. Fieldner.

The meeting then adjourned till 2 p. m.

TENTH SESSION—THURSDAY, JUNE 29, 2 P. M.

Corrosion of Metals

Mr. F. F. Farnsworth in the chair.

The report of Committee A-5 on Corrosion of Iron and Steel was presented by F. F. Farnsworth.

The revisions proposed for immediate adoption in the Standard Methods of Determining Weight of Coating on Zinc-Coated Articles (A 90 - 30) were unanimously approved for reference to letter ballot of the Society for adoption as standard, this recommendation requiring a nine-tenths vote. The Tentative Specifications for Zinc-Coated (Galvanized) Iron or Steel Telephone and Telegraph Line Wire (A 111 - 32 T), for Zinc-Coated (Galvanized) Iron or Steel Tie Wires (A 112 - 32 T), for Zinc-Coated (Galvanized) Iron or Steel Wire Strand (Cable) (A 112 - 32 T) and for Zinc-Coated Iron or Steel Chain-Link Fence Fabric Galvanized After Weaving (A 117 - 32 T) were approved for reference to letter ballot of the Society for adoption as standard to supersede the present standard specifications. In presenting the report Mr. Farnsworth called on E. S. Taylerson to describe the work of Subcommittee VII on Methods of Testing and on R. F. Passano to present the report of Subcommittee VIII on Field Tests of Metallic Coatings. Mr. Passano called attention to several modifications in the report of Subcommittee VIII which had been approved at a meeting of the subcommittee.

A paper entitled "Consistent Data Showing the Influence of Water Velocity and Time on the Corrosion of Iron," by R. F. Passano and F. R. Nagley, was presented by Mr. Passano and discussed.

The report of Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys was presented by the chairman, Jerome Strauss. Mr. Strauss also presented from manuscript the report of Subcommittee IV on Methods of Corrosion Testing.

The report of Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys was presented by the chairman, T. S. Fuller. In presenting the report Mr. Fuller called on W. H. Finkeldey to present the report of Subcommittee VI on Atmospheric Corrosion of Non-Ferrous Metals and Alloys and on C. L. Hippensteel to describe the work of Subcommittee VIII on Galvanic and Electrolytic Corrosion.

A paper entitled "Corrosion Resistance of Structural Aluminum," by E. H. Dix, Jr., was presented by the author and discussed.

The report of the Sectional Committee on Zinc Coating of Iron and Steel was presented by the chair. The proposed Tentative Specifications for Zinc Coating (Hot-Dip) on Hardware and Fastenings were accepted for publication as tentative. The revisions proposed for immediate adoption in the Standard Specifications for Zinc (Hot-Galvanized) Coatings on Structural Steel Shapes, Plates and Bars and Their Products (A 123 - 30) were unanimously approved for reference to letter ballot of the Society for adoption as standard, this recommendation requiring a nine-tenths vote.

The meeting then adjourned till the following morning.

Round Table Discussion on Spectrographic Analysis

Mr. O. S. Duffendack in the chair.

A Round Table Discussion on Spectrographic Analysis was held on Thursday afternoon, June 29, at 2 p. m. In introducing this first general discussion before the Society on the subject of spectrographic analysis, Mr. Duffendack, chairman of the round table discussion, reviewed briefly the activities of Committee E-2 on Spectrographic Analysis under whose auspices the round table discussion had been arranged. The discussion was then introduced by the following program of papers on major topics concerning the use of spectrographic methods for the testing and analysis of materials and its industrial applications:

"Spectrographic Instrumentation," by T. A. Wright—presented by the author.

"Methods of Quantitative Spectrography," by O. S. Duffendack—presented by the author.

"Accessory Uses of the Spectrograph," by C. C. Nitchie—presented by the author.

Written discussions were also read from Dr. F. Twyman, Managing Director of Adam Hilger, Ltd., of London, England, and from the British Non-Ferrous Metals Institute. The meeting was then opened to general discussion.

Open Meeting, Committee on Interpretation and Presentation of Data

Mr. Anson Hayes in the chair.

An open meeting of the Committee on Interpretation and Presentation of Data was held on Thursday afternoon, June 29, at 3 p. m. Anson Hayes, chairman of the technical committee briefly described the work of the committee and stated that the principal effort of the committee during the past year following its round table discussion at the 1932 annual meeting[1] had been directed to the preparation of a Manual on Presentation of Data. He then introduced H. F. Dodge who presented from manuscript the Manual on Presentation of Data. The Manual, prepared especially for the guidance and instruction of authors of technical papers and reports to be presented before the Society, embodies recommendations for one general type of data—a series of observations of a single variable obtained under the same essential conditions—and discusses the importance of using efficient functions of the data in summarizing the essential information contained therein.

A discussion on Collection and Interpretation of Data was then introduced by the following papers:

"Quality Control in Practice Using Inspection Results," by S. M. Osborne and P. S. Olmstead—presented by Mr. Osborne and discussed.

"Planning for the Collection of Standardization Data," by J. R. Townsend—presented by the author and discussed.

The chairman in summarizing the activities and work of the technical committee announced that the committee had made substantial progress in the formulation of a long range program having to do with the use of scientific methods in the collection, analysis, interpretation and presentation of data.

ELEVENTH SESSION—FRIDAY, JUNE 30, 9.30 A. M.

Non-Ferrous Metals

(Held Simultaneously with Twelfth Session)

Vice-President W. H. Bassett in the chair.

The report of Committee B-2 on Non-Ferrous Metals and Alloys was presented by the secretary, E. E. Thum. The report including the following recommendations of the committee was approved subject to a favorable letter ballot of Committee B-2:[1]

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 13 (1932).

The revision proposed for immediate adoption in the Standard Specifications for Slab Zinc (Spelter) (B 6 – 18) was unanimously approved for reference to letter ballot of the Society for adoption as standard, this recommendation requiring a nine-tenths vote. The editorial revisions of the Standard Methods of Chemical Analysis of Manganese Bronze (B 27 – 19), of Gun Metal (B 28 – 19), of Brass Ingots and Sand Castings (B 45 – 27) and of Bronze Bearing Metal (B 46 – 27) were approved. The Tentative Specifications for Fire-Refined Copper Other than Lake (B 72 – 32 T) and Methods of Chemical Analysis of Silver Solders (B 81 – 31 T) were approved for reference to letter ballot of the Society for adoption as standards.

It was announced that the committee had completed an extensive revision of the Tentative Methods of Chemical Analysis of Aluminum and Light Aluminum Alloys (B 40 – 28 T) and had prepared a proposed method for the determination of phosphorus as a tentative revision of the Standard Methods of Chemical Analysis of Brass Ingots and Sand Castings (B 45 – 27) which would be submitted to the Society during the summer through Committee E-10 on Standards.

A paper entitled "The Effect of the Addition of Lead on the Hardness of Certain Tin-Base Bearing Alloys at Elevated Temperatures," by J. N. Kenyon was presented by the author and discussed.

A paper entitled "A Comparison of Certain White Metal Bearing Alloys Particularly at Elevated Temperatures," by C. E. Swartz and A. J. Phillips was presented by Mr. Swartz and discussed.

The report of Committee B-5 on Copper and Copper Alloys, Cast and Wrought was presented by the secretary, D. K. Crampton. The proposed revisions of the Standard Specifications for Composition Brass or Ounce Metal Sand Castings (B 62 – 28) and for Yellow Brass Sand Castings for General Purposes (B 65 – 28) which appeared in the report as preprinted were withdrawn. The Tentative Specifications for Seamless Copper Tubing, Bright Annealed (B 68 – 32 T), without revision, and for Copper Water Tube (B 88 – 32 T), as revised, were approved for reference to letter ballot of the Society for adoption as standards. The tentative revisions of the Standard Specifications for Seamless Admiralty Condenser Tubes and Ferrule Stock (B 44 – 29), for 70–30 Brass Condenser Tubes and Ferrule Stock (B 55 – 25), for Seamless Muntz Metal Condenser Tubes and Ferrule Stock (B 56 – 25), for Copper Plates for Locomotive Fire Boxes (B 11 – 18), for Copper Bars for Locomotive Staybolts (B 12 – 21), for Seamless Copper Boiler Tubes (B 13 – 18), for Copper Pipe, Standard Sizes (B 42 – 24), for Brass Pipe, Standard Sizes (B 43 – 24) and for Sheet High Brass (B 36 – 27) were approved for reference to letter ballot of the Society for advancement to standard.

Mr. Sam Tour then assumed the chair.

A paper entitled "The Effect of Sulfur and Iron on the Physical Properties of Cast Red Brass (85 Cu, 5 Sn, 5 Zn, 5 Pb)," by H. B. Gardner and C. M. Saeger, Jr. was presented by Mr. Gardner and discussed.

The report of Committee B-4 on Electrical-Heating, Electrical-Resistance and Electric-Furnace Alloys was presented by the chairman, Dean Harvey.

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[1] The returns of the letter ballot on these recommendations were favorable and are given in detail on page 227.

The Tentative Accelerated Life Test for Metallic Materials for Electrical Heating (B 76 - 29 T) and Test for Thermoelectric Power (B 77 - 30 T), as revised, were approved for reference to letter ballot of the Society for adoption as standards.

The report of Committee B-6 on Die-Cast Metals and Alloys was presented by the chairman, H. A. Anderson. The proposed revisions of the Tentative Specifications for Aluminum-Base Alloy Die Castings (B 85 - 31 T) and for Zinc-Base Alloy Die Castings (B 86 - 31 T) were accepted, the specifications as revised being continued as tentative.

The meeting then adjourned till 2 p. m.

TWELFTH SESSION—FRIDAY, JUNE 30, 9.30 A. M.

Cement, Gypsum

(*Held Simultaneously with Eleventh Session*)

Mr. R. E. Davis in the chair.

A paper entitled "Status of Specifications for Hydraulic Cements in the United States," by P. H. Bates was presented by J. R. Dwyer and discussed.

A paper entitled "The Effect of Adding Siliceous Material to Portland Cements upon Volume Changes, Compressive Strength and Heat Generation," by R. W. Carlson and G. E. Troxell was presented from manuscript by R. E. Davis and discussed.

The report of Committee C-1 on Cement was presented by the technical assistant, J. R. Dwyer. A motion, requiring a two-thirds vote of those voting, to submit to letter ballot of the Society for adoption as standard the Tentative Specifications for High-Early-Strength Portland Cement (C 74 - 30 T) resulted in 18 affirmative and 21 negative votes and accordingly failed of adoption.

A paper entitled "A Rapid Method for the Determination of the Specific Surface of Portland Cement," by L. A. Wagner was presented from manuscript by the author and discussed.

A paper entitled "The Durability of Cement Mortars; the Cement and Method of Testing Major Variables," by C. A. Hughes was presented from manuscript by G. C. Priester.

The report of Committee C-11 on Gypsum was presented by the secretary, H. J. Schweim. The Tentative Methods of Testing Gypsum and Gypsum Products (C 26 - 32 T) were approved for reference to letter ballot of the Society for adoption as standard to supersede the present standard specifications. The tentative revision of the Standard Specifications for Gypsum Partition Tile or Block (C 52 - 27) was approved for reference to letter ballot of the Society for advancement to standard. The withdrawal of the Standard Specifications for Gypsum Wall Board (C 36 - 25) and for Gypsum Plaster Board (C 37 - 30) was approved, subject to favorable letter ballot of Committee C-11,[1] since these specifications are replaced by existing tentative specifications.

An informal progress report of the Sectional Committee on Specifications for Plastering was presented by the Assistant Secretary.

The meeting then adjourned till 2 p. m.

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[1] The withdrawal of the standard specifications was referred to letter ballot of Committee C-11 which consists of 28 members; 23 members returned their ballots all of whom voted affirmatively.

THIRTEENTH SESSION—FRIDAY, JUNE 30, 2 P. M.

Concrete

President Cloyd M. Chapman in the chair.

The report of Committee C-9 on Concrete and Concrete Aggregates was presented by the chairman, R. W. Crum. The proposed Tentative Specifications for Ready Mixed Concrete and Method of Test for Absorption by Aggregates (Laboratory Determinations) and Method of Field Tests for Absorption of Mixing Water by Aggregates for Concrete were accepted for publication as tentative. The proposed Specifications for Light-Weight Aggregates which appeared in the report as preprinted were withdrawn by the committee. The tentative revisions of the Standard Methods of Making and Storing Compression Test Specimens of Concrete in the Field (C 31 - 31), of Making Compression Tests of Concrete (C 39 - 27), of Test for Organic Impurities in Sands for Concrete (C 40 - 27) and of Test for Sieve Analysis of Aggregates for Concrete (C 41 - 24), were approved for reference to letter ballot of the Society for advancement to standard.

The following papers to be appended to the report were then presented from manuscript:

"The Action of Water on Concrete" by B. Kellam—presented by T. C. Powers.

"A Study of the Analysis of Fresh Concrete with the Dunagan Buoyancy Apparatus" by H. R. Nettles and J. M. Holme—presented by Inge Lyse and discussed.

The report on Significance of Tests of Concrete and Concrete Aggregates was introduced by A. N. Talbot, who stated that variations in materials and their sources of supply in various localities together with the variety of purposes and needs of the construction and in the methods used in the work all contribute to the importance of and the need for the making of tests for concrete materials. He stated that essentially there were three types of tests, acceptance tests, informational tests and investigational tests, each having important functions but requiring in the interpretation of their significance a full understanding with a good degree of judgment of their meaning and their limitations.

Mr. R. W. Crum as chairman of the special committee, of Committee C-9 on Concrete and Concrete Aggregates, in charge of assembling the report on significance of tests, then presented a brief abstract of the report which comprised the following subject matter:

Significance of Tests for Characteristics of Concrete:

Compression Tests. Inge Lyse.
Tensile and Transverse Strengths. A. T. Goldbeck.
Shearing and Torsional Strength. A. T. Goldbeck.
Elastic Properties. F. E. Richart.
Durability. C. H. Scholer.
Wear Tests. C. H. Scholer.
Workability. J. C. Pearson.
Volume Changes. R. E. Davis and J. W. Kelly.
Uniformity. R. L. Bertin.
Routine Analysis of the Cement Content of Hardened Portland-Cement Concrete. H. F. Kriege.

Significance of Tests for Characteristics of Aggregates:

Gradation, Specific Gravity, Unit Weight and Voids of Concrete. Fred Hubbard.
Deleterious Substances. F. C. Lang.
Soundness of Aggregates. Stanton Walker.
Free Moisture and Absorption. Bert Myers.
Abrasion Tests of Aggregates. H. F. Clemmer.
Mortar Strength Tests of Fine Aggregates. F. H. Jackson.

The Numbers of Specimens or Tests Required for Reasonable Accuracy of the Average. R. W. Crum.

A paper entitled "Further Studies of Paving Concrete," by F. H. Jackson and W. F. Kellermann was presented by Mr. Jackson and discussed.

Mr. R. W. Crum then assumed the chair.

A paper entitled "Apparatus for Fabricating and Testing Mass-Concrete Cylinders," by R. F. Blanks and E. N. Vidal was presented from manuscript by F. E. Richart.

A paper entitled "Calorimeter Installation in the Engineering Materials Laboratory of the University of California for Studies of Heat Generation in Mass Concrete," by S. B. Biddle, Jr., and J. W. Kelly was presented by R. E. Davis and discussed.

A progress report of Committee C-13 on Concrete Pipe was presented by the Assistant Secretary.

President Cloyd M. Chapman then assumed the chair.

A vote of thanks was, on motion, extended to the Chicago District Committee for their untiring efforts in making the necessary arrangements for the annual meeting.

There being no further business President Chapman then declared the Thirty-sixth Annual Meeting adjourned *sine die.*

INTRODUCTION

ANNUAL ADDRESS BY THE PRESIDENT

CLOYD M. CHAPMAN

JUNE 26, 1933

Alexander Pope said: "The proper study of mankind is man." I submit that a proper study of ASTM-kind is A.S.T.M.

Many of us, as individuals, in our daily work do a great deal of inspecting. Let us do some introspecting. I propose that we study, introspect and inspect our complex assembly,—that machine of which *we* are the parts, called A.S.T.M.,—somewhat after the manner in which many of us, as engineers, inspectors and research investigators, are in the habit of looking into, of inspecting, other more or less complex machines, materials and products. The purpose of this examination is to improve the machine and its products.

First, before we begin to inspect, let us consider the origin of this mechanism. How did it come about and why? In its beginnings, I view it as a thing that grew or developed in the divine scheme for the human race by the same sort of evolutionary process that has produced other phenomena, such as the motor industry, or the newer forms of government.

A.S.T.M. did not just happen suddenly. It is not the accidental offspring of a chance mating of different species of organisms, such as occasionally happens in nature. Nor is it a "sport," like the seedless fruits, red sunflowers or albino crows. It came into being by a slow and gradual process of evolution which was put in motion to meet a definite human need, to fill a gap in the ever-changing, ever-broadening design being woven by the Master Weaver, a design still in the making, a pattern of but bare outlines as yet, with many areas still to be filled in. Let us try to reconstruct this development.

As collective production of commodities gradually replaced home production, as the factory replaced the individual worker, there resulted a change in the commodities produced. So long as the cobbler, in his home, made by hand every part of a shoe to fit an individual, there were no two pairs alike. His pride in his skill, his jealousy of his reputation, his business sagacity, caused him to be sure that his materials were good, and that his handiwork was without flaw. He was his own inspector of materials and product. When he wanted a hide of leather, he went to his neighbor, the tanner, and selected the one best suited to his needs, whether for milady's slippers or milord's hunting boots. The remote ancestor of A.S.T.M.

When twenty cobblers worked together under one roof, each making one or more parts, or performing one or more operations, the shoes were practically alike; yet they still bore the marks of the individuals who had a hand in their making. No longer could each cobbler select and inspect his own raw materials, nor could each answer for the workmanship of the other nineteen. Someone had to select the hides and inspect the finished shoes, and that someone had to look for certain qualities and for certain defects. Whether consciously or unconsciously, that inspector and that buyer of hides had in his mind a specification. And while he may have used only his eyes and his fingers, he nevertheless had a method of test. The father of A.S.T.M.

When machinery replaced some of the twenty cobblers and parts were stamped out with dies and stitched by machines, every trace of the individual disappeared and every shoe became like every other shoe. The output, instead of being counted by pairs, is now counted by the gross or by the carload. No longer can one buyer examine every hide with his keen eye and experienced fingers. Nor can he select his materials from nearby sources. He must buy from a distance, perhaps from abroad. It becomes necessary to explain in writing exactly what he wants. He must have a specification. He writes his own, and some tanner of hides agrees to make him the kind of leather he wants, although the tanner has a little different idea of what the shoemaker ought to want, because for years he has been tanning leather for another shoe factory and he does not like this idea of making too many different kinds of leather. Why not use the same leather my other customer uses? And that was A.S.T.M. in its swaddling clothes.

The manufacturer and the user—the tanner and the cobbler—found it to their mutual advantage to agree on a quality of material for a certain purpose. When these two branches of industry—the maker and the user—first began to understand and to appreciate each other's requirements and viewpoints, the groundwork was being laid for the growth and development of A.S.T.M. It began to mature.

And as this cooperation grew and spread gradually into many lines of industry, so the value and usefulness of the idea grew and became recognized and finally resulted, since it happened in this machine age of ours, in the bringing together, assembling, if you please, in one test-and-specification-making machine the various working parts (you members) that up to that time had been serving separate industries, some serving manufacturers, others serving consumers. It was at this time—in 1902—that this new machine first came on the market. The first unit assembled was a rather crude affair, of limited usefulness and relatively few parts. Its parts related to metals, ferrous and non-ferrous, cement, brick and road materials; only nine working parts in this machine in the beginning.

But as the years went by and the designers worked over, remodeled, improved the parts and added new parts, the machine became more complex and at the same time more efficient and vastly more productive. Parts relating to rubber, textiles, stone, slate, tile, pipe, lime, gypsum, mortars, coatings, lubricants, coal and coke, timber, waterproofing, metallography and others, were added and coordinated with the whole, until now there are some 50 parts of this machine relating to every major industry in the country. It is still being improved, enlarged, and its efficiency is being steadily increased.

Let's have a look at it:

In its present stage of development it is our machine and we are its parts. Let us inspect it and examine it and perhaps we may be able to suggest some very worth-while improvements, for that is really the purpose lying back of this inspection.

In doing so let us consider it as a machine designed and built to turn out a certain line of products, namely, tests and specifications. We must, therefore, consider it from two angles: First we must look at the machine itself, keeping in mind its ability to turn out those products; and second, we must examine the quality of the products produced. For a machine must be judged not only by its own perfection of design, workmanship and smooth working, but also by the perfection of its output.

Let us review some of the items that must be covered and what to look for. Perhaps one of the first things that will occur to many of you—at least it would to me—is the general reputation of the machine, its past performance. Does it bear a high reputation in its field? Is there any other equal or better device capable of turning out the same or a better product? On this score you will find that our machine is unique in its field. Its reputation is firmly established at the top of its class. This is not because it is the only machine in use for turning out products in its line, but it has been found to be the best of them. We find evidence and recognition of this in the statutes of many states and in the ordinances and the codes of numerous municipalities. In fact, the further we pursue this line of investigation the more evidence we will find of the high reputation of its products.

Having decided that the product of the machine has merit, we take a look at the machine itself, its design, the quality of the material used, the coordination of its parts and their functioning one with another. We note whether there are useless parts which might be eliminated, whether there is duplication of parts which might be combined. In this particular inspection we find that the machine is made up of a number of major assemblies of parts called committees, the governing or controlling assembly being the executive committee; that directly connected to this governing assembly are some only slightly less important assemblies called administrative committees and that each of these performs a function different from that of the others, and that each has a designating mark plainly stamped on it. Closer inspection discloses that each of these assemblies is of carefully selected individual parts, of material chosen on the basis of ability to perform the special service of that particular part—a selected personnel.

We find that many other working assemblies, called technical committees, each plainly marked, and all more or less independent of one another, but flexibly connected to the governing assembly and to the administrative assemblies. On closer inspection one notices also the high quality and special selection of the material which goes to make up these working parts.

This matter of quality deserves careful scrutiny. A machine may be beautifully built for show purposes, with all parts carefully finished, smoothed, polished, plated and "dolled up," but these beautiful parts may not be of the best material for practical use, for long and reliable service. But this machine of ours, you find, is not a thing built for beauty, but for utility and serviceability. We are not prize winning beauties, but we can do hard work and a great deal of it, as witness the output over the years.

The next point we want to cover is whether this machine has adaptability. Can it produce but one product, or is it capable of varying its product to meet changing needs, markets or styles? Unless it is adaptable it will sooner or later be obsolete; which Heaven forbid, for an obsolete machine finds its best market among the junk dealers. Let us never sell out to the junk dealers!

Keeping it modernized will mean continuously altering the design of some of the assemblies, adding new and changing old parts. We must keep it up to date and capable of turning out a product that will be in demand, eagerly sought after, and which will please the customer.

Next, let us look into the speed of our machine, the time it takes to perform all the necessary operations from the time the raw material is fed to it until it turns out the finished product. Much has been done to improve this feature in the last few years, and more can undoubtedly still be done. In the earlier designs the partially finished product stopped for a time in storage bins, as it were, between successive operations, but now the progress from the first operation to the last is more steady and the total time is considerably reduced. Another feature has been added, a new assembly of parts has been attached to the governing assembly, which may be thrown into operation whenever there is a strong market demand for a particular product. The best time to have a product or a commodity for sale is when there is a strong demand for it. This recent improvement has made it possible to expedite the completion of a required product while the demand and the market are strong. Such improvements are bound to spread the fair name and fame of our machine.

And so we might go on with each of the fifty or more working assemblies of parts and examine their functions and their coordination with the other assemblies. That is what I hope each of you will do for the particular assembly with which you are connected, whether it be marked A-1 or B-2, or what not, and also for the machine as a whole.

In this machine age it has become very popular to give service with a product. If the product requires attention, repair or replacement of parts after it has passed from the producer to the consumer, it is common practice for the producer to follow up the product and see that it is satisfactory. We should and do perform this type of service. If our product is not fully satisfactory, we call it in and correct the defects—we bring it up to date. We discard old models and replace them with our latest product. Our aim should be to have no obsolete product in use. Periodically we should check up on these products and ascertain which of them are behind the times, out of date, unused, and promptly discard them, or offer new and up-to-date models in their place.

You and I are parts of this standards-making machine. The product is standard tests and specifications. It is an intelligent machine, and therein it differs from ordinary machines. It is a truly automatic machine in that it requires no direction or supervision from the outside.

We are not only the working parts of this machine, but we are responsible for its output, for its up-to-dateness, for improvements in both the machine and the product.

It is worthy of our careful and thoughtful study. If we are clever we can improve it.

Study A.S.T.M., inspect it and test it, strive to improve it to the highest degree of perfection.

ANNUAL REPORT OF THE EXECUTIVE COMMITTEE

The Executive Committee offers the following report of general Society activities for the year ending with this annual meeting:

Membership:

The membership of the Society on June 1, 1933, was 3733. Statistics showing gains and losses in the various classes of membership are as follows:

Class of Members	Membership		Losses				Additions		Total		
	June 1, 1932	June 1, 1933	Resignations	Dropped	Death	Transfer	Transfer	Election	Loss	Gain	Decrease
Honorary	4	3	...	...	1	..	..	...	1	...	1
Life or Perpetuity	11	11	...	...	..	..	..	...	...	...	...
Sustaining	5	6	...	...	..	..	1	...	...	1	1[a]
Company, Firm, etc	1026	901	90	33	..	31	2	27	154	29	125
Individual, etc	3037	2762	288	145	26	2	49	137	461	186	275
Junior	80	50	4	13	..	19	..	6	36	6	30
Total	4163	3733	382	191	27	52	52	170	652	222	430
Student	134	126	14	68	..	2	..	76	84	76	8

[a] Increase.

The net loss of 430 is larger than reported a year ago and shows very definitely the effect of prevalent industrial conditions upon this important phase of the Society's existence. Resignations and delinquencies have increased, and at the same time the number of new members elected has, despite the efforts of the staff, committees and many individual members, decreased below the number elected a year ago.

Many of the members, both individuals and companies, who have resigned during the past two years have stated that they were severing their connections with the Society only because of the business stringency; that they valued the Society's work and expected to renew their membership when conditions improved. Wherever possible, contact with such members has been maintained through the establishment of a special roll upon which is placed the name of any member, obliged to resign, who would like to continue to receive copies of the Bulletin and programs of meetings and in other ways to keep in touch with Society activities and publications. There are at present over 100 individuals and companies on this roll. Furthermore, the Executive Committee has recognized and met so far as it could the pressure on the financial resources of so many members at this time. It has extended the date by which members delinquent for the previous year's dues could make payment. Wherever special consideration was requested it has been granted. The annual dues may now be paid in two installments and, in the case of new members, payment of entrance fees may be spread over two years.

Naturally, some of those temporarily obliged to sever their connections with the Society have been active committee members, and in such cases arrangements have been made wherever desired for continued contact with committee work, without vote, but with full opportunity for the individual to render such services in the committee as he was able or willing under the circumstances to perform. In this and other ways the Executive Committee has sought to retain continued interest in and contact with Society activities on the part of all who have found themselves in these difficulties, confident that when the turn for the better comes many of these individuals and companies will resume their membership with unabated interest and faith in the value of the Society and its work.

Death has taken a heavy toll of the Society membership during the year; the following 27 members have passed away:

	DATE OF MEMBERSHIP		DATE OF MEMBERSHIP
Adamson, A. R.	1925	Lachiver, Mitchell E.	1922
Aldridge, Earl V.	1916	McClintock, James R.	1919
Binzen, John P.	1916	Meehan, G. F.	1918
Burgess, George K.	1915	Miller, John	1931
Carroll, Daniel	1924	Miller, Lee H.	1929
Edwards, W. F.	1919	Olsen, Oscar M.	1922
Ellerbeck, W. L.	1920	Olsen, Tinius	1898
Eustus, W. E. C.	1910	Perry, R. S.	1907
Fraser, Alexander	1917	Petts, George E.	1929
Glover, George J.	1909	Poole, William	1932
Goes, Edward F.	1916	Tagge, Arthur C.	1915
Hayward, H. W.	1906	Webster, William R.	1898
Kelley, Frederick W.	1910	Wood, Edwin T.	1910
Kichline, Frank O.	1923		

Many of these members were distinguished in service in the Society. William R. Webster, one of the charter members and an honorary member of the Society, was a pioneer in the organization of committee work and served for many years on the Executive Committee. Tinius Olsen was one of the first members of the American

Section of the old International Association, dating from 1898. George K. Burgess was a distinguished past-president of the Society. W. F. Edwards and Frederick W. Kelley had been members of the Executive Committee and actively engaged in our technical work. Others who had been active in the work of the Society were W. L. Ellerbeck, H. W. Hayward, F. O. Kichline, L. H. Miller, R. S. Perry, A. C. Tagge and E. T. Wood.

The future of Society membership is of greatest importance. The technical work of the Society, even in these times, is growing; we must match it with a growing membership if the work is to be done. It was not, of course, to be expected that the Society could go through the worst industrial period in the history of the nation without feeling to greater or lesser degree the strain of membership losses, and the concurrent reduction in funds with which to carry on its work. The membership on June 1 as reported above, 3733, is about 15 per cent less than the peak of Society membership, which was 4417 in 1930. The loss, while considerable and creating serious problems of administration and finance, is not unduly large in view of the conditions. Much of it can and we believe will be regained with improvement in industry and business in general, but that in itself will not be enough. We must work with renewed efforts to stem the tide of present losses, and to take every advantage of the impending business recovery to forge ahead in membership growth. So important does this whole matter appear to the Executive Committee and so necessary does it seem to ensure substantial growth of Society membership during the coming years, that it has been decided to appoint a Special Committee on Membership to plan and direct membership work during these years of industrial recovery. Much consideration of the matter in the Executive Committee has brought the conviction in the minds of its members, ably expressed in recent Bulletin articles by the President and by Arthur W. Carpenter, that the most effective means of extending Society membership is through *the personal efforts of our members*, and it will be the principal task of the Special Committee to stimulate to this end the unquestioned interest in the Society and its welfare on the part of hundreds of our members and to mobilize and coordinate the several channels through which this work must be done, such as the standing committees, the several district committees, and the staff. The personnel of the Special Committee is now being selected, and the Executive Committee earnestly bespeaks in advance for the committee the sincere and cordial support of the membership.

Under existing business conditions it has been felt to be impracticable and indeed unwise actively to solicit Sustaining Memberships at annual dues of $100 established by amendment of the By-laws in 1931. Sufficient assurance was given at that time by member companies of the Society to warrant a definite feeling of optimism that this method of increasing financial support of the Society activities, that are of such definite and direct value to industrial companies and organizations to whom we must look for this class of membership, can be successfully established under normal business conditions. The importance of this class of membership becomes of greater significance in view of the membership losses that have been sustained in the past two years. There are at present six Sustaining Members of the Society, namely, The Texas Company, Socony-Vacuum Corp., Bell Telephone Laboratories, Universal Atlas Cement Co., Sun Oil Co., and Western Electric Co., Inc. The Executive Committee expresses its appreciation of the interest in the work of the Society that prompts these organizations to give this added support to the Society's activities.

The importance of Student Membership has been stressed on a number of occasions. As announced in issues of the Society Bulletin during the year, prize awards have been established by several members of the Society in the form of memberships to students at the following technical schools: Cornell University, three memberships; Lehigh University, ten memberships; Massachusetts Institute of Technology, five memberships; Rensselaer Polytechnic Institute, five memberships· University of Pennsylvania, five memberships. These memberships are of unquestioned value to the students and, of course, it means much to the Society to have the young engineer and chemist acquainted at first hand with the value that the Society can be to him in his work. Many future members of the Society are the students of today and the Executive Committee hopes to see this method extended to other schools by interested members of the Society.

Committee Activities:

The work of the Society as exemplified in the activities of its committees has gone forward during the year in a most gratifying way. Indeed it is a splendid tribute to the industrial and technical importance of this work that it has progressed with such little interruption under present conditions. It will be evident from the current reports that many standardization and research projects have been carried on as planned; many new specifications and methods of test are being offered for Society action, and revisions and advancement of tentative standards recommended in anticipation of the publication of the new edition of the Book of Standards. As usual, the reports of two administrative committees, E-9 on Research and E-10 on Standards, supplemented by reviews in the July and October issues of the A.S.T.M. Bulletin, will give a general summary of these activities, so that the present report will deal only with administrative committee matters.

One new committee was organized during the year, namely, Committee C-13 on Concrete Pipe. The organization of this committee came about through the decision reported a year ago to divide the former Committee C-4 on Clay and Concrete Pipe into two committees dealing separately with these two kinds of pipe. Certain questions affecting the jurisdiction of Definitions of Terms Relating to Sewer Pipe (C 8 – 24) and Recommended Practice for Laying Sewer Pipe (C 12 – 19), in which both committees are interested, are still under consideration in the Executive Committee.

The scope of Committee D-15 on Thermometers has been enlarged to include all apparatus composed wholly or largely of glass utilized in A.S.T.M. methods; the new title of the committee is Committee D-15 on Thermometers and Laboratory Glassware. There is need for standardization in this larger field and the committee with enlarged personnel will function in an advisory capacity to other committees of the Society specifying various types of glass apparatus in their methods. All such committees have the opportunity of representation on Committee D-15 and have been asked to refer glassware problems to the committee for its recommendations.

Acting favorably upon recommendations of Committee E-10 on Standards, the Executive Committee has increased the membership of that committee from five to six and established a term of membership of three years with provision that the terms of two members shall expire each year.

The Executive Committee has also decided that it would be advisable to extend the authority of Committee E-10 on Standards to permit it to pass upon and accept for publication as tentative proposed revisions of existing standards submitted between annual meetings of the Society. The amendments of the By-laws required for such extension of authority are proposed elsewhere in this report for Society action.

Mr. J. R. Dwyer was reappointed a member of the Society's staff for one year ending October 31, 1933, and assigned to Committee C-1 on Cement as its technical assistant under the arrangement previously announced, whereby funds for his salary and traveling and other expenses as technical assistant are made available by Committee C-1.

In line with the announced policy, Committee A-1 on Steel has arranged for the part time services of a member of the Society's staff as staff assistant to the committee officers, supplemented by technical and stenographic services as needed. The expenses are being met from funds contributed by the committee.

The Executive Committee has taken cognizance of difficulties experienced by a few committees in holding meetings during the year, due to the stress of industrial conditions, and consequent inability to conform strictly to certain rules of procedure. Several instances involved adoption as standard of tentative standards without revision and of tentative revisions of existing standards without revision, and in these cases the Executive Committee authorized the standing committees concerned to conduct the required letter ballot vote of the membership without the necessity of holding a meeting of the committee. In other ways the Executive Committee has sought to facilitate the standardization work of the Society during these times without, however, eliminating any of the essential requirements or safeguards in the standardization procedure.

Two questions affecting patented apparatus have been settled during the year. Satisfactory assurance having been given to the Executive Committee by the Wilson Mechanical Instrument Co., manufacturers of the Rockwell Hardness Tester, that the monopoly based upon present patents will not result in exorbitant prices for this instrument to the consuming public, the Executive Committee has authorized the development of Society specifications involving the use of the Rockwell Hardness Tester where desired by Society committees and has approved the publication of the Methods of Rockwell Hardness Testing of Metallic Materials (E 18 – 32 T).

The Executive Committee has executed for the Society a new agreement with the Sinclair Refining Co., owners of the patents on the Union Colorimeter, authorizing an exclusive license to the Tagliabue Manufacturing Co. to manufacture this instrument in accordance with the specifications of the Society. The Executive Committee has reserved authority to review questions of cost and selling price.

An agreement has recently been concluded between the Society, the Coöperative Fuel Research Committee and the Waukesha Motor Co., granting to the latter an exclusive license for the manufacture and sale for three years of the C.F.R. Engine specified in the A.S.T.M. Tentative Method of Test for Knock Characteristics of Motor Fuels (D 357 – 33 T) and authorizing the company to use a combined A.S.T.M.-C.F.R. emblem on each engine. The company has obligated itself to meet the specifications for the engine or such modifications as may be approved by the C.F.R. committee and the Society jointly and to sell the engine at a price in keeping with cost plus a fair profit. A more detailed account of the agreement was published in the April, 1933, Bulletin.

Meetings:

The fourth Regional Meeting of the Society was held March 8, 1933, in New York under the auspices of the New York District Committee. The technical feature was the Symposium on Motor Lubricants sponsored by Committee D-2, in which the Metropolitan Section of the Society of Automotive Engineers cooperated. An informal dinner was one of the features of the meeting. As usual, the spring group meetings of committees were held during the same week and despite the difficulties incident to the countrywide closing of banks, both the Regional and Committee Meetings were well attended and the committee work, so important to a successful annual meeting, was carried on most satisfactorily. In fact these and all other committee meetings during the year showed evidence of a very sincere and purposeful attitude of all members towards their important responsibilities and gave evidence also of the desire of the many industries participating in Society work that promotion of knowledge of materials and standardization of specifications and methods are needed and should progress.

Difficulties imposed by stringent financial and industrial conditions slowed down local activities, especially meetings sponsored by the several district committees. Only one such local meeting was held, namely, a meeting under the auspices of the New York District Committee on November 17, 1932, at which several papers on Timber and Timber Preservatives were presented under the sponsorship of Committee D-7 on Timber. Much interest was expressed in these papers, which have been published either in full or in abstract in various technical journals.

These local activities in recent years have contributed greatly to the interest in Society activities in the several localities in which they have been held, and the Executive Committee is confident that under more favorable conditions each district committee will find it possible to sponsor at least one local meeting annually at which an interesting and worth-while program on some suitable materials subject is presented.

Publications:

Since the last annual meeting the following publications distributed to the members were issued: the Proceedings, including preprints of reports and papers, the 1932 Supplement to the 1930 Book of A.S.T.M. Standards, the Index to A.S.T.M. Standards and Tentative Standards, and a Supplement to the Year Book containing names of all new members and the complete revised personnel of the standing committees. The Book of A.S.T.M. Tentative Standards and the Symposium on Rubber containing the papers and discussions presented at the Cleveland Regional Meeting in March, 1932, were published and furnished to members on order. A comparative statement of the volume of these publications for the past four years follows:

	1929, pages	*1930, pages*	*1931, pages*	*1932, pages*
Proceedings	1937	2421	2416	1895
Book of A.S.T.M. Standards	....	2214	....	....
Supplement to Book of A.S.T.M. Standards	293	....	144	102
Year Book	320	332	342	....
Supplement to Year Book	....	....	....	133
Index to A.S.T.M. Standards and Tentative Standards	109	113	103	119
Book of A.S.T.M. Tentative Standards	901	864	1008	1236
Regional Meeting Symposium	....	186	152	159
Joint A.S.M.E.–A.S.T.M. Symposium on Effect of Temperature on the Properties of Metals	....	....	829	....
	3560	6130	4724	3644

Reference is made to the annual report of Committee E-6 on Papers and Publications for further details, including a number of reprints from the 1932 publications and the preprinting of regional meeting papers for the Symposium on Motor Lubricants and the preprinting of reports and papers for the present annual meeting. A new Refractories Manual was issued last year at the request of Committee C-8 on Refractories, comprising the A.S.T.M. specifications and methods of test for refractories and the Manual for Interpretation of Refractory Test Data prepared by the committee. This publication has been given a very gratifying reception throughout the refractory industry and is finding a useful place in the schools of ceramic engineering.

It has been decided to adopt generally the policy of imprinting on A.S.T.M. standards and tentative standards suitable notation, where applicable, indicating that they have also been adopted by other national organizations.

A study of the possibility of publishing a monthly technical journal of the Society was completed during the year by Committee E-6 on Papers and Publications. It has been decided that the Society should not undertake the publication of such a journal at this time, but that the A.S.T.M. Bulletin should be gradually expanded in content as finances permit and so developed as to provide a still better and more frequent means of contact between the Society and its membership. So far as strictly technical papers and the annual reports of committees are concerned, it is felt that the present methods of publication in separate form either as preprints or reprints and their inclusion in the bound annual Proceedings is satisfactorily meeting the needs of the Society and its members. On the other hand there is much material of merely temporary or current interest that it is believed could be published advantageously in an enlarged Bulletin, such as "general information" papers, papers of promotional value relating to standards and research, and interim and progress reports of committees. Specifications and methods, suggested test procedures, etc., which committees desire to publish for information might more suitably be published in the Bulletin than in the Proceedings as at present. In general, the contents of the Proceedings might be more strictly limited to reports and papers of permanent reference value, and more material of purely current interest be brought to the membership through the Bulletin. There is need for publication of methods of test suggested by members and exchange of information between members on matters relating to specifications and tests that could be met by the contemplated enlargement of the Bulletin. Further study is being given to the editorial and publication matters involved.

Proposed Amendment of the By-laws:

The Executive Committee proposes the following amendments of Section 1, Article VI, "Procedure Governing Adoption of Standards" of the By-laws to make effective the desired enlargement of the scope of authority of Committee E-10 on Standards mentioned in an earlier section of this report, and recommends that these modifications be referred by the annual meeting to the required letter ballot of the membership of the Society:

In Section 1, Paragraph (*a*), change the reference in the first sentence to "Paragraph (*b*)" to read "Paragraph (*c*)."

Change the present Paragraph (*b*), new Paragraph (*c*), to read as follows by insertion of the italicized words and the deletion of the words in brackets:

(*c*) Proposed new standards, [or] proposed amendments of existing tentative standards, *or proposed amendments of existing standards*, may also be presented between annual meetings, in which case they shall be reviewed by the Committee on Standards, which shall determine whether all requirements relating to the preparation and submission of standards have been complied with and whether the standing committee has reached a substantial consensus in its recommendations to the Society. If such review is satisfactory to the Committee on Standards, it may accept the proposed new standards or proposed amendments of existing *standards or* tentative standards for publication as tentative [standard]. During consideration of and action upon the recommendations of a standing committee, two designated representatives of the standing committee shall serve as members of the Committee on Standards, with full privileges of discussion and vote. At the annual meeting following the publication of a tentative standard or amendment under this procedure, the standing committee concerned shall report the acceptance of the tentative standard or amendment, which shall be subject to amendment at that annual meeting by a two-thirds vote of those voting. Tentative standards *or amendments of existing standards* reported at an annual meeting for the first time shall normally be continued as tentative.

Change the first sentence of the present Paragraph (*c*), new Paragraph (*b*), to read as follows by the insertion of the italicized words:

(*b*) Proposed amendments of existing standards, *except as provided in Paragraph* (*c*), shall be presented at an annual meeting, at which they may be amended by a two-thirds vote of those voting.

Finances:

Report for the Fiscal Year 1932.—The annual statement of the finances of the Society follows in the report of the auditors for the fisal year January 1 to December 31, 1932.

The outstanding financial feature of the year 1932 was the fact that, despite considerably reduced income from membership dues and, to a relatively lesser extent, from sales of publications, it was possible to effect such economies in the operations of the Society without serious curtailment of publications and other services as to keep current disbursements within current receipts. The net decrease in membership for the year and the greater number of delinquent members reduced income from dues about $10,000 below that for 1931. For the first time during the industrial depression there was a marked falling off in sales of the Book of Standards and separate standards, which was partly offset by increased sales of the many special publications, notably the various compilations of standards and reports relating to specific industrial fields. Advertising income for the Bulletin held up well throughout the year. The net effect was to reduce 1932 income by about $10,500 from that budgeted at the beginning of the year. Disbursements were pared accordingly. Substantial savings were made in the costs of printing and distributing the various Society

REPORT OF THE AUDITORS—JANUARY 1 TO DECEMBER 31, 1932

PHILADELPHIA, January 9, 1933.

AMERICAN SOCIETY FOR TESTING MATERIALS

Gentlemen:

We respectfully report that we have made an audit and examination of the books and accounts of your Society for the seven months ended December 31, 1932, having previously made a similar audit and report for the preceding five months ended May 31, 1932, and at both audits found the accounts to be correct and to be in excellent condition.

We submit herewith balance sheet as of December 31, 1932, as also a statement of cash receipts and disbursements for the twelve months then ended.

We have verified the transactions set forth in the budget record for the seven months ended December 31, 1932, as also for the five months ended May 31, 1932, as reported in ours of June 15, 1932, and found the same to be correct.

We have verified by actual inspection and count the securities as scheduled under Investments and report all interest collected to December 31, 1932, with the exception of the interest due November 1, 1932, on $2000 Pennsylvania Railroad second 5's, which coupons were detached from the bonds, in our presence at the time of our inspection January 7, 1933, and were then deposited.

Respectfully submitted,

(Signed) JOHN HEINS AND CO.

BALANCE SHEET AS OF DECEMBER 31, 1932

ASSETS				
Current Funds			$5 945.05	
Investments			49 035.80	
Accounts Receivable:				
For Publications		$5 067.79		
Advertising		1 565.00		
Members, for 1932 Dues		5 093.65		
Members for Entrance Fees		97.50		
Members, for Binding		33.50		
Miscellaneous		28.34		
			11 885.78	
A.S.T.M.-A.S.M.E. Symposium on Effect of Temperature:				
Special Account for Financing Book			2 948.23	
Furniture and Fixtures			6 301.67	
				$76 116.53
LIABILITIES				
Publications paid for in advance		$62.60		
Advertising paid for in advance		16.00		
Members Dues paid in advance		655.52		
Members Binding paid in advance		34.00		
Entrance Fees paid in advance		70.00		
			$838.12	
Contributions from Committee C-1 for Technical Assistant			184.27	
International Assn. for Testing Materials			137.90	
Income, A.S.T.M. Research Fund			917.32	
Life Membership Fund	$3 005.20			
A.S.T.M. Research Fund	8 179.35			
Headquarters Fund	5 030.00			
Carried forward	$16 214.55		$2 077.61	

Brought forward	$16 214.55		$2 077.61	
Publications Fund	3 015.00			
Book of Standards Reserve	11 743.20			
		$30 972.75		
Surplus		43 066.17		
			74 038.92	
				$76 116.53

RECEIPTS AND DISBURSEMENTS
JANUARY 1, 1932, TO DECEMBER 31, 1932

Current Funds, January 1, 1932			$6 414.07
RECEIPTS			
Current Dues	$69 242.84		
Past Dues	744.90		
Advance Dues	655.52		
Income, Life Membership Fund	150.00		
Entrance Fees	1 875.00		
Total Dues		$72 668.26	
Separate Standards	$2 830.18		
Book of Standards	3 459.69		
Book of Standards—Members for both parts	242.00		
Book of Tentative Standards	3 554.70		
Proceedings	3 159.46		
Collective Index to Proceedings	538.01		
Selected Standards for Students	1 058.70		
Miscellaneous (including special reprints)	11 599.65		
Total Sales of Publications		26 442.39	
Binding (Members)		456.00	
Advertising in Bulletin		4 463.73	
Advertising in Index to Standards and Tentative Standards		495.00	
Authors' Reprints		614.53	
Sale of Certificates of Membership		20.00	
Interest on Deposits and Investments		3 460.29	
Investments matured or sold		22 397.25	
Accrued interest		238.76	
Excess Remittances		270.36	
Symposium on Effect of Temperature		2 276.84	
Income, A.S.T.M. Research Fund		415.00	
Registration and other fees, Annual Meeting		799.00	
International Association for Testing Materials, Dues		659.00	
International Assn. for Testing Materials, Publications and Deficit		532.58	
Committee C-1 for Technical Assistant		1 666.67	
Committees A-5 and B-3 towards special publications		1 045.00	
Seaview Golf Club (see disbursements)		61.15	
A.F.A. Share Malleable Iron Castings Symposium		455.31	
A.F.A. Share Steel Castings Symposium		724.68	
Total Receipts			140 161.80
Carried forward			$146 575.87

Brought forward			$146 575 87

DISBURSEMENTS

Publications:			
Year Book	$1 096.92		
Book of Standards	146.00		
Book of Standards Supplement	980.86		
Selected Standards for Students	434.88		
Book of Tentative Standards	2 958.82		
Proceedings	18 334.65		
Preprints	2 747.12		
Bulletin and Circular to Members	5 043.27		
Separate Standards	1 291.45		
Index to Standards and Tentative Standards	1 191.43		
Regional Meeting Papers	996.06		
Collective Index to Proceedings	1 493.48		
Miscellaneous (including special reprints)	6 971.75		
		$43 686.69	
Salaries		42 217.69	
General Office Expenses		8 359.85	
Expenses, Standing Committees		2 565.91	
Expenses, Meetings		1 975.40	
Traveling Expenses—Administrative Committees		1 398.64	
Rent and Insurance, Storage Rooms		471.00	
Rent, Headquarters		3 000.00	
Headquarters Maintenance		229.10	
Furniture and Fixtures		429.92	
Certificates of Membership		18.50	
American Standards Assn. and Sectional Committees		1 900.00	
Investments:			
Book of Standards Reserve	6 052.50		
Miscellaneous	21 127.72		
		27 180.12	
Accrued interest		267.10	
Seaview Golf Club (see receipts)		61.15	
Refund of Excess Remittances		270.36	
Symposium on Effect of Temperature		1 972.60	
Symposium on Steel Castings (A.F.A. Share)		742.18	
International Assn. for Testing Materials, Dues		573.00	
International Assn. for Testing Materials, Publications and Deficit		394.97	
Franklin Memorial Museum Subscription		200.00	
Technical Assistant, Committee C-1		2 653.54	
Miscellaneous		63.10	
Total Disbursements			140 630.82
Balance, Current Funds, December 31, 1932			$5 945.05

Balance, Current Funds, December 31, 1932		$5 945.05
Less, amount to provide for difference between cost of $15,000 Baltimore & Ohio 4½'s due 1933 less 10 per cent paid by company during year carried as current funds, January 1, 1932, and the net market value of these bonds carried as current funds, December 31, 1932		4 900.00
Balance		**$1 045.05**
Balance accounted for as follows:		
Cash on hand	$245.05	
Investments carried as cash:		
$15 000 Baltimore & Ohio R. R. Bonds 4½'s due 1933 (cost $15 000 less 10 per cent paid by company) carried at market value 12.31.32	8 600.00	
1 000 U. S. Liberty Bonds 4th 4¼'s due 1938	1 000.00	
	$9 845.05	
Less checks drawn but not paid against cost of Proceedings.	$8 800.00	
		$1 045.05

MISCELLANEOUS FUNDS

In addition to the regular Society funds the Secretary-Treasurer has on hand the following funds, accounted for as follows:

Committee A-1 on Steel	$63.55	
Committee A-3 on Cast Iron	29.31	
Committee A-5 on Corrosion of Iron and Steel	6 527.42	
Committee A-5, Subcommittee X on Embrittlement Investigation	127.46	
Committee B-3 on Corrosion of Non-Ferrous Metals	3 655.58	
Committee B-6 on Die-Cast Metals and Alloys	256.47	
Committee C-1 on Cement	890.10	
Committee C-1, Cement Reference Laboratory	783.43	
Committee C-9 on Concrete and Concrete Aggregates	606.37	
Committee C-10 on Hollow Masonry Building Units	245.23	
Committee D-1 on Preservative Coatings	31.94	
Committee D-14 on Screen Wire Cloth	53.72	
Committee D-18 on Natural Building Stones	24.27	
Joint Committee on Investigation of Phosphorus and Sulfur in Steel	384.43	
A.S.A. Sectional Committee on Cast-Iron Pipe	3 300.16	
A.S.A. Sectional Committee on Classification of Coals	1 146.42	
Total Committee Funds		$18 125.86

DUDLEY MEDAL AND MARBURG LECTURE FUND

Balance, January 1, 1932:		
Investments	$6 977.50	
Cash on hand	984.07	
		$7 961.57
RECEIPTS		
Interest on Deposits and Investments		369.20
		$8 330.77
DISBURSEMENTS		
Cost of 1932 Medal	$80.00	
Honorarium, 1932 Lecturer	200.00	
Engrossing 1932 Lecture Certificate	3.25	
Miscellaneous	22.56	
		305.81
		$8 024.96
Less difference in book value of investments due to transfer of securities		352.50
		$7 672.46
Balance, December 31, 1932:		
Investments	$6 625.00	
Cash on hand	1 047.46	
		$7 672.46

FINANCIAL CONDITION AT CLOSE OF FISCAL YEARS 1928–1932, INCLUSIVE.

Fiscal Year	Assets				Liabilities			
	Current Funds	Investments	Accounts Receivable and Miscellaneous	Furniture and Fixtures	Accounts Payable and Miscellaneous	Reserve for Book of Standards	Special Funds	Surplus
1928	$978.56	$44 752.09	$6 831.10	$5 327.09	$972.04	$6 057.80	$10 354.30	$40 504.70
1929	3 683.76	54 707.09	6 226.93	5 896.31	1 913.27	12 012.80	19 438.05	37 149.97
1930	4 567.78	44 255.51	10 873.38	6 209.36	2 935.58	....	20 438.05	42 532.40
1931	6 414.07	49 946.21	12 668.06	6 571.94	3 905.00	5 690.70	19 438.05	46 566.53
1932	5 945.05	49 035.80	14 834.01	6 301.67	2 077.61	11 743.20	19 229.55	43 066.17

INVESTMENTS, DECEMBER 31, 1932

SOCIETY FUNDS

			Book Value	Market Value
General:				
$10 000	N. Y. C. Refunding and Improvement Bonds, 5's due 2013		$5 108.55	$4 300.00
4 500	Baltimore & Ohio R. R. 20 year Convertible Bonds, 4½'s due 1933		4 156.55	2 592.00
2 000	Penna. R. R. Bonds, Seconds, 5's due 1964		2 000.00	1 590.00
3 000	Am. Tel. & Tel. Co. S. F. Deb. Bonds, 5's due 1960.		3 159.75	3 188.00
500	Consolidated Gas Co. of N. Y. Bonds, 20 year 5½'s due 1945		531.00	533.00
6 000	Southeastern Power & Light Co. 6's Gold Deb. Bonds, Series A, due 2025		6 240.00	4 170.00
7 000	Baltimore & Ohio R. R. Refunding and General Mortgage Bonds, 5's due 1995		7 087.50	2 625.00
6 000	Missouri Pacific R. R. First and Refunding Mortgage 5's Gold Bonds, Series F, due Mar. 1, 1977		5 690.70	1 305.00
7 000	U. S. Liberty Bonds, 4th, 4¼'s, due 1938		7 070.00	7 258.00
$46 000			$41 044.05	$27 561.00
A.S.T.M. Research Fund:				
$3 000	Baltimore & Ohio R. R. Refunding and General Bonds, 5's due 1995		$3 037.50	$1 125.00
1 500	Baltimore & Ohio R. R. 20 year Convertible Bonds, 4½'s due 1933		1 361.25	864.00
1 500	Consolidated Gas Co. of N. Y. Bonds, 20 year 5½'s, due 1945		1 593.00	1 599.00
2 000	First Mortgage Real Estate, 6's Bonds on 1315–17 Spruce St., due 1945		2 000.00	2 000.00
$8 000			$7 991.75	$5 588.00
54 000			49 035.80	33 149.00
Dudley Medal and Marburg Lecture Fund:				
$500	Baltimore & Ohio R. R. Refunding and General Bonds, 6's due 1995		$550.00	$200.00
6 000	Baltimore & Ohio R. R. Refunding and General Bonds, 5's due 1995		6 075.00	2 250.00
$6 500			$6 625.00	$2 450.00
Committee Funds:				
$6 000	U. S. Liberty Bonds, 4th, 4¼'s, due 1938:			
	Committee A-5	$5 610.39		
	Committee C-1	509.53	$6 119.92	$6 221.00
$66 500			$61 780.72	$41 820.00

publications, all of which were published as usual except the Year Book, in place of which a Supplement to the 1931 edition was published. Reductions in general office and miscellaneous expense, including travel, telephone and telegraph, administrative committees and furniture and fixtures, were effected; considerable savings were made in the expenses of the annual meeting by modification in methods of printing the program, elimination of the printed registration list, and curtailment of entertainment expense; a reduction in salaries was made effective from July 1, 1932; and, finally, no investment was made from current funds towards the principal of the A.S.T.M. Research Fund, for under present conditions it is considered more important to conserve funds for publications than to increase the Research Fund.

As a result, the Society was able to operate within its current income and did not have to call upon its surplus, nor upon a favorable balance of $5200 from previous years' operations that had been set aside as a contingency fund.

The report of the auditors gives the balance sheet of assets and liabilities, statement of receipts and disbursements, and comparison of the financial position of the Society at the close of the past five years. It also gives statements of funds held for the accounts of committees, and of the Dudley Medal and Marburg Lecture Fund. Investments of Society and other funds are listed, both book and market values being given. A better diversification of holdings in railroad bonds was effected by exchange of $10,000 Baltimore & Ohio Bonds Refunding and General 6's for like amount of New York Central Bonds Refunding and Improvement 5's at substantially the same price, and later (March, 1933) by the refunding of the Baltimore & Ohio Convertible Bonds 4½'s 50 per cent in cash and 50 per cent in Refunding and General Mortgage 5's. There was no default in 1932 on any of the securities in the Society portfolio; but since April, 1933, the bonds of the Missouri Pacific, of which the Society holds $6000, have been in default.

The Society has been fortunate in that its current funds in checking account and several savings accounts have not been affected by the recent banking difficulties.

No account has been taken in the accompanying financial statement of the assets of the Society in the form of publications in stock, with one exception, namely, the cost value, $2948.23, of the copies still in stock of the joint A.S.M.E.-A.S.T.M. Symposium on Effect of Temperature on the Properties of Metals purchased by the Society from the joint account described a year ago; this amount is included in the statement of assets. The inventory of technical publications on June 1, 1933, may be summarized approximately as follows:

		NUMBER OF COPIES
Proceedings		6 300
Index to Proceedings	Vols. I-XII, incl	490
	Vols. XIII-XX, incl	655
	Vols. 21-25, incl	625
	Vols. 26-30, incl	370
Book of A.S.T.M. Standards	Part I, Metals	2 150
	Part II, Non-Metals	2 125
1931 Supplement to Book of A.S.T.M. Standards		3 500
1932 Supplement to Book of A.S.T.M. Standards		800
Book of A.S.T.M. Tentative Standards		230
Index to Standards and Tentative Standards		400
Selected Standards for Students in Engineering		1 200
Selected Standards for Students in Chemistry, Chemical Engineering and Metallurgy		450
Reprints of 441 Standards (approximate)		25 000
Symposium on Effect of Temperature on the Properties of Metals		830
Special Reprints (approximate)		23 000

1933 Finances.—In budgeting Society operations for 1933, the Executive Committee has been faced with much uncertainty respecting probable income. Membership losses due to resignations and delinquencies have continued, but there is good assurance of maintaining income from sales of publications. Income from advertising in the Bulletin has fallen off this year, and while such income may reasonably be expected to pick up with improvement in business conditions, this cannot safely be counted upon now. Net income from the Second Exhibit of Testing Apparatus and Equipment has been uncertain. In brief, the Executive Committee concluded that until actual conditions prove otherwise it must be assumed that 1933 will be a difficult year financially, and that in any event the Society will show some "lag" behind industrial recovery when it comes. Accordingly, the budget of receipts and disbursements was set up at the beginning of the year on a tentative basis, subject to review and adjustment of disbursements within actual income, supplemented by such reserve funds as may be safely and properly used. A sum of approximately $7000, available from favorable balances in the past three years, is being applied to this year's operation, but it is desired not to draw upon other reserve funds except as an emergency. Disbursements totalling approximately $116,750 (equivalent to estimated income) have been tentatively budgeted, providing for the usual publications and activities. Full provision has been made for the publication of the 1933 edition of the Book of Standards, and there has been no curtailment in publication of new and revised standards representing the work of the committees during the year. The number of technical papers on the program is slightly smaller than in recent years and it has been necessary to curtail somewhat the amount of preprinting. Further printing economies are being effected and general office, traveling, committee and meeting expenses are being kept to a minimum. The annual contribution to the American Standards Association has for a time been reduced from $1500 to $1000. The reduction in salaries effective since last July has been continued during the present year. The Executive Committee will review the entire budget at the time of the annual meeting, when it should be possible to predict total income with reasonable certainty and balance the budget for the year.

Headquarters:

The present quarters of the Society in the Engineers' Club Building have been recognized for some time to be in many ways inadequate and consideration was given last summer to the possibility of establishing more suitable offices elsewhere at the conclusion of a five-year lease with the Engineers' Club that expired December 31, 1932. Several promising possibilities were studied, but inasmuch as any move into adequate quarters would materially increase rental expense, it was thought inadvisable under present financial conditions to incur such increased expense. The Society accordingly renewed its lease with the Engineers' Club for the present quarters for the year ending December 31, 1933, at a reduced annual rental, with option to renew for another year.

Exhibit of Testing Apparatus and Equipment:

As announced in recent issues of the A.S.T.M. Bulletin, the Second Exhibit of Testing Apparatus and Equipment is being held in conjunction with this annual meeting. Experience at the first such exhibit two years ago was most favorable; and the plan of exhibiting commercial apparatus of manufacturers and distributors and non-commercial apparatus developed in research, government and university laboratories, together with exhibits of committee work in the apparatus field, gave very definite scientific and educational atmosphere that was appreciated by the membership and by all who participated in the exhibit. The same policies have governed the plans for the Exhibit this year; and while the industrial depression has had the effect of reducing the number of exhibitors materially below that of two years ago, there is every expectation that the

Exhibit will fulfill the objectives that the Executive Committee has formulated for it as an educational feature of the annual meeting of outstanding interest to the members and committees of the Society and of direct substantial value to the exhibitors.

Cooperative Work with Other Societies:

It is a well-established principle of the Society's work that it cooperates to the fullest extent with other national societies and technical and industrial associations interested in the study and specifying of materials. Our standardization procedure is based upon cooperation of consumer, producer and general interest and to an increasing extent the interests of producer and of consumer are given expression through regional or national organizations, notably through the activities of trade associations. Cooperative relations with other organizations, therefore, are viewed by the Executive Committee as of major importance and every effort is made to facilitate such cooperative work to the end that the work of the Society in its established field of materials shall be made most effective and useful to all such groups. It is a pleasure to record that these cooperative contacts are being continually extended.

An important development of this kind during the year was the arranging for direct representation on many committees of the Society of the National Electrical Manufacturers Association, which acquired a Society membership for the purpose, thus bringing directly and effectively to the deliberations of our committees the views and experience of the electrical manufacturing industry in the development of specifications and methods of test of materials in which they are interested either as producers or consumers.

It is expected that arrangements will be consummated this fall for official representation of the Society of Automotive Engineers on A.S.T.M. committees dealing with the development of standards for non-ferrous metals and alloys of interest to the automotive field and, conversely, representation of A.S.T.M. on committees of the S.A.E. Division on Non-Ferrous Metals and Alloys, in order that the present correlation of standards of the two organizations in this field, which is already considerable, may be continued as effectively as possible.

Special committees of the Society and of the American Concrete Institute are considering means of effecting closer cooperation and coordination between the two societies, particularly in those fields of standardization where the activities of the two societies necessarily touch and at times overlap.

Many other cooperative contacts are recorded in the reports of committee activities and currently in the Society Bulletin. One of the most significant of these is the Society's cooperation with the American Foundrymen's Association during the past three years in jointly sponsoring symposiums on cast ferrous metals for the purpose of bringing together reliable and authentic data on properties of these metals of interest and value alike to foundrymen and to the many and varied users of these products.

The Society's work in the American Standards Association is, of course, one of its outstanding cooperative activities. Reference is made to the current report of Committee E-10 on Standards for details of these activities. The Society's representatives on the Standards Council are J. A. Capp and A. A. Stevenson, with F. M. Farmer and the Assistant Secretary as alternates.

In the realm of international cooperative work, the Society has appointed representatives on various "study commissions" of the International Association for Testing Materials, as announced from time to time in the A.S.T.M. Bulletin. These commissions have been formed to provide effective means of interchange of information and data on properties and tests of materials and to this end the Society has expressed its entire willingness to participate to the fullest extent. It has not, however, authorized its representatives on these commissions to vote or in other ways to commit the Society to any agreements in these commissions, since it is believed that the International Standards Association, essentially a federation of national standardizing bodies, with which the Society cooperates through the American Standards Association, is in a more effective position to bring about international agreement on methods of testing supported by authoritative action of national bodies. The Executive Committee has presented a statement of its views to the officers of the I.A.T.M. and has expressed its belief that the activities of the I.A.T.M. commissions should be limited to studies and researches in the field of materials and exchange of information between various countries.

Mr. W. H. Fulweiler has been appointed American member of the Permanent Committee of the I.A.T.M., succeeding Dr. George K. Burgess upon the latter's death.

Respectfully submitted on behalf of the Executive Committee,

CLOYD M. CHAPMAN,
President.

C. L. WARWICK,
Secretary-Treasurer.

REPORT OF COMMITTEE A-1
ON
STEEL

The single meeting held by Committee A-1 on Steel during the past year was exceptionally well attended, with many subcommittees meeting in conjunction therewith. Despite the fact that only one meeting was held instead of the customary three, important progress was made on the many problems concerning steel and steel products under the jurisdiction of the committee, including many recommendations affecting the standards under its jurisdiction.

Since the 1932 annual meeting, 15 new members have been elected and 10 resignations were accepted, the committee now having a total membership of 192, of which 86 are classified as producers, 79 as consumers and 27 as general interests.

The Tentative Specifications for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83 - 32 T), submitted by Committee A-1 at the 1932 annual meeting and intended to replace when adopted the present standard specifications, were revised subsequent to the 1932 annual meeting and the revision presented to the Society through Committee E-10 on Standards. The specifications in their revised form were accepted for publication as tentative by Committee E-10 at a meeting held on August 11, 1932,[1] and appear in the 1932 *Proceedings*.[2]

RECOMMENDATIONS AFFECTING STANDARDS

Recommendations of the committee affecting standards and tentative standards are presented first in summarized form together with an analysis of the letter ballot of each item. Where necessary, these recommendations are referred to further, being grouped for convenience in the order of the subcommittees responsible for them.

I. Proposed Tentative Standards.—The committee recommends that the following proposed new tentative specifications be accepted for publication as tentative as appended hereto:[3]

Proposed Tentative Specifications for Heat-Treated Steel Elliptical Springs
Proposed Tentative Specifications for Alloy-Steel Castings for Structural Purposes

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[1] In submitting these revised tentative specifications to Committee E-10, the committee reported results of the letter ballot vote as follows: Of a total membership of 191, 114 members returned their ballots, of whom 74 voted affirmatively and 1 negatively.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 549 (1932); also 1932 Book of A.S.T.M. Tentative Standards, p. 98.

[3] See pp. 564, 553, 572, 533, 539.—ED.

Proposed Tentative Specifications for Lap-Welded and Seamless Steel Pipe for High-Temperature Service

Proposed Tentative Specifications for High Tensile Strength Carbon-Steel Plates for Pressure Vessels (Plates 2 in. and under in Thickness)[1]

Proposed Tentative Specifications for High Tensile Strength Carbon-Steel Plates for Fusion-Welded Pressure Vessels (Plates over 2 in. up to and Including 4 in. in Thickness)[1]

II. Proposed Revision of Standards.—The committee recommends for immediate adoption revisions, given in detail in the Appendix to this report, of the following standards. The committee accordingly asks for the necessary nine-tenths vote at the annual meeting in order that these revisions may be submitted to letter ballot of the Society for immediate adoption:

Standard Specifications for Structural Steel for Bridges (A 7 – 29)

Standard Specifications for Structural Steel for Buildings (A 9 – 29)

Standard Specifications for Billet-Steel Concrete Reinforcement Bars (A 15 – 30)[2]

Standard Specifications for Rail-Steel Concrete Reinforcement Bars (A 16 – 14)[2]

Standard Specifications for Welded and Seamless Steel Pipe (A 53 – 30)

Standard Specifications for Boiler and Firebox Steel for Locomotives (A 30 – 24)

Standard Specifications for Boiler and Firebox Steel for Stationary Service (A 70 – 27)

Standard Specifications for Commercial Quality Hot-Rolled Bar Steels (A 107 – 30)

Standard Specifications for Commercial Cold-Finished Bar Steels and Cold-Finished Shafting (A 108 – 30)

Standard Specifications for Steel Plates of Structural Quality for Forge Welding (A 78 – 30)

Standard Specifications for Carbon-Steel Castings for Valves, Flanges and Fittings for High-Temperature Service (A 95 – 29)

Standard Specifications for Alloy-Steel Bolting Material for High-Temperature Service (A 96 – 31)

Standard Specifications for Forged or Rolled Steel Pipe Flanges for High-Temperature Service (A 105 – 28)

A revision in the Standard Specifications for Cold-Drawn Steel Wire for Concrete Reinforcement (A 82 – 27) is further recommended for publication as tentative for one year, as given in the Appendix, before referring it to letter ballot of the Society for adoption.

III. Proposed Revision of Tentative Standards.—The committee recommends that the following specifications be revised, as given in detail in the Appendix and the specifications as revised continued as tentative:

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[1] Submitted at annual meeting, see Summary of Proceedings, p. 11; also Editorial Note, p. 63. —Ed.

[2] Revision submitted at annual meeting, see Summary of Proceedings, p. 14; also Editorial Note p. 65.—Ed.

Tentative Specifications for Normalized and Tempered Alloy-Steel Forgings for Locomotives (A 133 - 31 T)
Tentative Specifications for Structural Medium Steel (A 140 - 32 T)

The committee further proposes a revision, given in detail in the Appendix, of the Tentative Specifications for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83 - 32 T). These specifications are being recommended for adoption as standard, but this revision is recommended for publication as tentative for one year.

IV. Adoption of Tentative Standards as Standard.—The committee recommends that the following nine tentative standards be adopted as standard, with revisions in the last three specifications listed, as given in detail in the Appendix:

Tentative Specifications for Soft Steel Track Spikes (A 65 - 32 T)
Tentative Specifications for Structural Rivet Steel (A 141 - 32 T)
Tentative Specifications for Marine Boiler Steel Plates (A 114 - 29 T)
Tentative Specifications for Structural Steel for Ships (A 131 - 31 T)
Tentative Specifications for Heat-Treated Carbon-Steel Helical Springs (A 125 - 31 T)
Tentative Specifications for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83 - 32 T)
Tentative Specifications for Austenitic Manganese-Steel Castings (A 128 - 30 T), as revised
Tentative Specifications for Open-Hearth Iron Plates of Flange Quality (A 129 - 30 T), as revised
Tentative Specifications for Steel Plates of Flange and Firebox Qualities for Forge Welding (A 89 - 32 T), as revised

V. Advancement of Tentative Revision of Standards to Standard.—The committee recommends the advancement to standard of the tentative revisions proposed last year[1] in the following standards:

Standard Specifications for Low-Carbon-Steel Splice Bars (A 3 - 24)
Standard Specifications for Quenched Carbon-Steel Track Bolts (A 50 - 24)
Standard Specifications for Quenched Alloy-Steel Track Bolts (A 51 - 21)
Standard Specifications for Steel Screw Spikes (A 66 - 21)
Standard Specifications for Low-Carbon-Steel Track Bolts (A 76 - 27)
Standard Specifications for Steel Tie Plates (A 67 - 30)
Standard Specifications for Structural Steel for Buildings (A 9 - 29)
Standard Specifications for Structural Silicon Steel (A 94 - 29)
Standard Specifications for Billet-Steel Concrete Reinforcement Bars (A 15 - 30)
Standard Specifications for Rail-Steel Concrete Reinforcement Bars (A 16 - 14)
Standard Specifications for Cold-Drawn Steel Wire for Concrete Reinforcement (A 82 - 27)
Standard Specifications for Welded and Seamless Steel Pipe (A 53 - 30)
Standard Specifications for Commercial Quality Hot-Rolled Bar Steels (A 107 - 30)

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, pp. 79, 973 (1932); also 1932 Book of A.S.T.M. Tentative Standards, p. 1117.

Standard Specifications for Commercial Cold-Finished Bar Steels and Cold-Finished Shafting (A 108 – 30)

VI. Withdrawal of Standards.—The committee recommends the withdrawal of the Standard Specifications for Cold-Rolled Steel Axles (A 22 – 21);[1] and the Standard Specifications for Lap-Welded and Seamless Steel Pipe for High-Temperature Service (A 106 – 29).[1]

VII. List of Specifications for Steel Suitable for Fusion Welding.—It is recommended that the List of Specifications for Steel Suitable for Fusion Welding, appended hereto,[2] be published in the Book of A.S.T.M. Standards.

Submission of Standards to American Standards Association.—The committee is recommending that the following standard specifications be submitted to the American Standards Association for approval as American Standards:

Standard Specifications for Carbon-Steel Castings for Valves, Flanges and Fittings for High-Temperature Service (A 95 – 29)

Standard Specifications for Alloy-Steel Bolting Material for High-Temperature Service (A 96 – 31)

Standard Specifications for Forged or Rolled Steel Pipe Flanges for High-Temperature Service (A 105 – 28)

The recommendations in this report have been referred to letter ballot of the committee which consists of 192 members. The analysis of the vote is given in Table I.

ACTIVITIES OF SUBCOMMITTEES

The recommendations previously listed, as well as the other features of the committee's work, are discussed below grouped in the order of the respective subcommittees responsible.

Each subcommittee having jurisdiction over specifications referring to the bessemer process has recommended the advancement to standard of the tentative revision proposed last year[3] in the process clause, which will provide that references to the bessemer process be changed to read "acid-bessemer process."

Subcommittee I on Steel Rails and Accessories (E. F. Kenney, chairman).—This subcommittee is recommending the adoption as standard of the Tentative Specifications for Soft Steel Track Spikes (A 65 – 32 T),[4] and also of the tentative revisions proposed last year[5] in the Standard Specifications for Steel Tie Plates (A 67 – 30).

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[1] 1930 Book of Standards, Part I, pp. 205, 278, respectively.

[2] See 1933 Book of A.S.T.M. Standards, Part I, p. 77.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, 68 (1932).

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 531 (1932); also 1932 Book of A.S.T.M. Tentative Standards, p. 27.

[5] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 79 (1932)

TABLE I.—ANALYSIS OF LETTER BALLOT VOTE.

Items	Affirmative	Negative	Not Voting
I. PROPOSED TENTATIVE STANDARDS			
Specifications for Heat-Treated Steel Elliptical Springs	62	0	58
Specifications for Alloy-Steel Castings for Structural Purposes	76	1	43
Specifications for Lap-Welded and Seamless Steel Pipe for High-Temperature Service[a]	65	15	40
Specifications for High Tensile Strength Carbon-Steel Plates for Pressure Vessels (Plates 2 in. and Under in Thickness)	72	0	49
Specifications for High Tensile Strength Carbon-Steel Plates for Fusion-Welded Pressure Vessels (Plates over 2 in. Up to and Including 4 in. in Thickness)	73	0	48
II. PROPOSED REVISION OF STANDARDS			
Specifications for Structural Steel for Bridges (A 7 – 29), immediate adoption	75	1	44
Specifications for Structural Steel for Buildings (A 9 – 29), immediate adoption	75	1	44
Specifications for Billet-Steel Concrete Reinforcement Bars (A 15 – 30), immediate adoption	70	1	50
Specifications for Rail-Steel Concrete Reinforcement Bars (A 16 – 14), immediate adoption	70	1	50
Specifications for Welded and Seamless Steel Pipe (A 53 – 30), immediate adoption	79	2	39
Specifications for Boiler and Firebox Steel for Locomotives (A 30 – 24), immediate adoption	80	0	40
Specifications for Boiler and Firebox Steel for Stationary Service (A 70 – 27), immediate adoption	80	0	40
Specifications for Commercial Quality Hot-Rolled Bar Steels (A 107 – 30), immediate adoption	80	1	39
Specifications for Commercial Cold-Finished Bar Steels and Cold-Finished Shafting (A 108 – 30), immediate adoption	71	1	48
Specifications for Steel Plates of Structural Quality for Forge Welding (A 78 – 30), immediate adoption	78	0	42
Specifications for Carbon-Steel Castings for Valves, Flanges and Fittings for High-Temperature Service (A 95 – 29),[b] immediate adoption	67	13	40
Specifications for Alloy-Steel Bolting Material for High-Temperature Service (A 96 – 31),[b] immediate adoption	67	13	40
Specifications for Forged or Rolled Steel Pipe Flanges for High-Temperature Service (A 105 – 28),[b] immediate adoption	67	13	40
Specifications for Cold-Drawn Steel Wire for Concrete Reinforcement (A 82 – 27)	63	0	57
III. PROPOSED REVISION OF TENTATIVE STANDARDS			
Specifications for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83 – 32 T)	71	4	45
Specifications for Normalized and Tempered Alloy-Steel Forgings for Locomotives (A 133 – 31 T)	70	0	50
Specifications for Structural Medium Steel (A 140 – 32 T)	75	1	44
IV. ADOPTION OF TENTATIVE STANDARDS AS STANDARD			
Specifications for Soft Steel Track Spikes (A 65 – 32 T)	60	0	60
Specifications for Structural Rivet Steel (A 141 – 32 T)	81	1	38
Specifications for Marine Boiler Steel Plates (A 114 – 29 T)	61	0	59
Specifications for Structural Steel for Ships (A 131 – 31 T)	60	0	60
Specifications for Heat-Treated Carbon-Steel Helical Springs (A 125 – 31 T)	70	0	50
Specifications for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83 – 32 T)	74	0	46
Specifications for Austenitic Manganese-Steel Castings (A 128 – 30 T), as revised	67	0	53
Specifications for Open-Hearth Iron Plates of Flange Quality (A 129 – 30 T), as revised	66	0	54
Specifications for Steel Plates of Flange and Firebox Qualities for Forge Welding (A 89 – 32 T), as revised	79	0	41
V. ADVANCEMENT OF TENTATIVE REVISION OF STANDARDS TO STANDARD			
Specifications for Low-Carbon-Steel Splice Bars (A 3 – 24)	61	0	59
Specifications for Quenched Carbon-Steel Track Bolts (A 50 – 24)	61	0	59
Specifications for Quenched Alloy-Steel Track Bolts (A 51 – 21)	61	0	59
Specifications for Steel Screw Spikes (A 66 – 21)	61	0	59
Specifications for Low-Carbon-Steel Track Bolts (A 76 – 27)	61	0	59
Specifications for Steel Tie Plates (A 67 – 30)	62	0	58
Specifications for Structural Steel for Buildings (A 9 – 29)	78	0	42
Specifications for Structural Silicon Steel (A 94 – 29)	74	0	46
Specifications for Billet-Steel Concrete Reinforcement Bars (A 15 – 30)	62	2	56
Specifications for Rail-Steel Concrete Reinforcement Bars (A 16 – 14)	60	2	58
Specifications for Cold-Drawn Steel Wire for Concrete Reinforcement (A 82 – 27)	63	0	57
Specifications for Welded and Seamless Steel Pipe (A 53 – 30)	81	1	38
Specifications for Commercial Quality Hot-Rolled Bar Steels (A 107 – 30)	80	1	39
Specifications for Commercial Cold-Finished Bar Steels and Cold-Finished Shafting (A 108 – 30)	71	1	48
VI. WITHDRAWAL OF STANDARDS			
Specifications for Cold-Rolled Steel Axles (A 22 – 21)	68	0	52
Specifications for Lap-Welded and Seamless Steel Pipe for High-Temperature Service (A 106 – 29)[c]	65	15	40
VII. APPROVAL OF LIST OF SPECIFICATIONS			
List of Specifications for Steel Suitable for Fusion Welding	95	0	25

[a] The classified vote on the Tentative Specifications for Lap-Welded and Seamless Steel Pipe for High-Temperature Service was as follows: Affirmative: 26 producers, 30 consumers, 9 general interests; negative: 10 producers, 5 consumers, 0 general interests; not voting: 21 producers, 14 consumers, 5 general interests.

[b] The classified vote on the adoption of the revisions in the Standard Specifications A 95, A 96 and A 105 was as follows: Affirmative: 29 producers, 30 consumers, 8 general interests; negative: 9 producers, 4 consumers, 0 general interests; not voting: 19 producers, 15 consumers, 6 general interests.

[c] The classified vote on the withdrawal of the Standard Specifications A 106 was as follows: Affirmative: 26 producers, 30 consumers, 9 general interests; negative: 10 producers, 5 consumers, 0 general interests; not voting: 21 producers, 14 consumers, 5 general interests.

Subcommittee II on Structural Steel for Bridges, Buildings and Rolling Stock (A. W. Carpenter, chairman).—This subcommittee has recommended for adoption as standard the Tentative Specifications for Structural Rivet Steel (A 141 – 32 T).[1] When these become standard, the rivet requirements in the Standard Specifications for Structural Steel for Bridges (A 7 – 29), Structural Steel for Buildings (A 9 – 29), and Structural Steel for Locomotives and Cars (A 113 – 29) are to be deleted.

The subcommittee is proposing for immediate adoption, revisions in the Standard Specifications for Structural Steel for Bridges (A 7 – 29), the Standard Specifications for Structural Steel for Buildings (A 9 – 29) and the Tentative Specifications for Structural Medium Steel (A 140 – 32 T). These revisions, which provide requirements for rolled base plates, including the elimination of physical test requirements for such plates, are given in the Appendix.

It has been recommended that a special committee be appointed to consist of representatives from the several subcommittees interested in specifications for rivet steel, namely, Subcommittees II, III and XI, to study the possibility of combining all rivet specifications into one specification containing all the necessary categories of rivet steel.

Subcommittee III on Structural Steel for Ships (R. C. Davis, chairman).—This subcommittee is recommending for adoption as standard the Tentative Specifications for Marine Boiler Steel Plates (A 114 – 29 T)[2] and the Tentative Specifications for Structural Steel for Ships (A 131 – 31 T).[3] The latter, when adopted as standard, will supersede the present Standard Specifications for Structural Steel for Ships (A 12 – 21) and for Rivet Steel for Ships (A 13 – 24).

Subcommittee IV on Spring Steel and Steel Springs (H. W. Faus, chairman).—This subcommittee is recommending for adoption as standard the Tentative Specifications for Heat-Treated Carbon-Steel Helical Springs (A 125 – 31 T).[3] The proposed Tentative Specifications for Heat-Treated Steel Elliptical Springs, appended hereto,[4] developed by this subcommittee, are recommended for publication as tentative.

Subcommittee V on Steel Reinforcement Bars (H. H. Morgan, chairman).—Because it was found inadequate and inequitable both to consumers and producers to operate on a weight tolerance divided unequally between over and under variations from specified or theoretical weights, a revision was agreed upon as given in the Appendix to be recommended for immediate adoption in the weight tolerance requirements of the Standard Specifications for Billet-Steel Concrete Reinforcement Bars (A 15 – 30) and for Rail-Steel Concrete Reinforcement Bars (A 16 – 14) which provides for uniform under and over permissible weight variations depending on the thickness of the bar. Tentative revisions[1] issued in 1932, other than those involving weight tolerances, in these specifications are also recommended for advancement to standard.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 540 (1932); also 1932 Book of A.S.T.M. Tentative Standards, p. 36.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 561 (1929); also 1932 Book of A.S.T.M. Tentative Standards, p. 50.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, pp. 641, 654 (1931); also 1932 Book of A.S.T.M. Tentative Standards, pp. 39, 65.

[4] See p. 564.—ED.

This subcommittee further recommends a tentative revision in the Standard Specifications for Cold-Drawn Steel Wire for Concrete Reinforcement (A 82 – 27). This revision, which is given in the Appendix, involves tolerances on wire diameter and the inclusion of a yield point requirement in the tension test.

Subcommittee VI on Steel Forgings and Billets (R. W. Steigerwalt, chairman).—This subcommittee is presenting a revision of the Tentative Specifications for Normalized and Tempered Alloy-Steel Forgings for Locomotives (A 133 – 31 T). This revision, given in the Appendix, provides for a stated minimum yield point in place of the present requirement which is given in percentage of the tensile strength.

The Standard Specifications for Cold-Rolled Steel Axles (A 22 – 21)[2] have been found to be in disuse, since no cold-rolled steel axles are now being made, and it is accordingly recommended that they be discontinued.

Subcommittee VIII on Steel Castings (W. C. Hamilton, chairman).—This subcommittee is recommending for publication as tentative the proposed Specifications for Alloy-Steel Castings for Structural Purposes, appended hereto.[3] The Tentative Specifications for Austenitic Manganese-Steel Castings (A 128 – 30 T) are recommended for adoption as standard, including the immediate adoption of the proposed revisions given in the Appendix.

The Tentative Specifications for Electric Cast-Steel Stud-Link Anchor Chain (A 77 – 28 T) were placed under the jurisdiction of Subcommittee VIII. Because of the special nature of the material which they cover, no changes are recommended and they will be continued as tentative.

Subcommittee IX on Steel Tubing and Pipe (H. H. Morgan, chairman).—To bring the elongation requirements of the Standard

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, pp. 80, 976 (1932); also 1932 Book of A.S.T.M. Tentative Standards, p. 1120.

[2] 1930 Book of A.S.T.M. Standards, Part I, p. 205.

[3] See p. 553.—ED.

Specifications for Welded and Seamless Steel Pipe (A 53 – 30) in line with other specifications for pipe, Subcommittee IX is recommending for immediate adoption as standard the proposed revision, given in the Appendix, involving a reduction of the elongation requirement for open-hearth low-carbon seamless pipe from 40 per cent to 30 per cent.

The Tentative Specifications for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83 – 32 T) are recommended for adoption as standard, to supersede the present Standard Specifications A 83 – 30. A revision in the marking clause of these specifications has been recommended for publication as tentative for a year. This revision, given in the Appendix, provides that tubes of small diameter and in short lengths may be bundled and the specified marking be stamped on a tag attached to the bundle.

Subcommittee XI on Boiler Steel (E. J. Edwards, chairman).—This subcommittee recommends the adoption as standard of the Tentative Specifications for Open-Hearth Iron Plates of Flange Quality (A 129 – 30 T), with a revision in the marking clause to provide for the marking of thin plates or sheets by means of stenciling. A similar revision in the marking clauses of the Standard Specifications for Boiler and Firebox Steel for Locomotives (A 30 – 24) and for Boiler and Firebox Steel for Stationary Service (A 70 – 27) is also proposed for immediate adoption.

In the latter two specifications, revisions in the scope clause and in the section covering the homogeneity test are recommended for immediate adoption as standard. The revisions in the scope clause limit the thickness of plates to which the specifications apply. The specifications had been referred to in the purchase of plates several inches in thickness, and since the specifications are not applicable, temporary measures have been taken to limit them to plates not over 2 in. in thickness. Requirements for heavier plates will be written later. The changes in the section covering the homogeneity test will limit the present requirements to plates not over $\frac{3}{4}$ in. in thickness and provide requirements for thicker plates. These revisions are given in the Appendix.

Because of the apparent urgency for specifications covering high tensile strength plates for pressure vessel construction, especially desired by the Boiler Code Committee of the A.S.M.E., Subcommittee XI has prepared proposed Tentative Specifications for High Tensile Strength Carbon-Steel Plates for Pressure Vessels (Plates 2 in. and Under in Thickness) and for High Tensile Strength Carbon-Steel Plates for Fusion-Welded Pressure Vessels (Plates over 2 in. up to and Including 4 in. in Thickness). Committee A-1 at its June, 1933, meeting approved the submission of these specifications, appended hereto,[1] to the Society for publication as tentative.

Subcommittee XV on Commercial Bar Steels (J. J. Shuman, chairman).—This subcommittee is recommending for immediate adoption revisions in the Standard Specifications for Commercial Quality Hot-Rolled Bar Steels (A 107 – 30) and for Commercial Cold-Finished Bar Steels and Cold-Finished Shafting (A 108 – 30) to provide for closer tolerances to bring them in line with those adopted by the manufacturers of hot-rolled and cold-finished bars, respectively. A revision is also recommended in Specifications A 108 to include shafting up to 8 in. in diameter. These revisions are given in the Appendix.

Subcommittee XIX on Sheet Steel and Steel Sheets (A. L. Davis, chairman).—Changes are being studied by Subcommittee XIX in the Tentative Specifications for Cold-Rolled Strip Steel (A 109 – 27 T) which will make the specifications of distinct practical value. These revisions will be developed during the next year.

Subcommittee XXI on Steel for Welding (F. N. Speller, chairman).—This subcommittee recommends the adoption as standard of the Tentative Specifications for Steel Plates of Flange and Firebox Qualities for Forge Welding (A 89 – 32 T) together with a revised homogeneity test clause and a revision in the marking clause to provide for the marking of thin plates or sheets by means of stenciling. These specifications will supersede, when adopted, the present Standard Specifications for Steel Plates of Flange Quality for Forge Welding (A 89 – 30). The subcommittee is also presenting for immediate adoption as standard, as given in the Appendix, revisions in the notes in the Tentative Specifications A 89 – 32 T and in the Standard Specifications for Steel Plates of Structural Quality for Forge Welding (A 78 – 30), which refer to the use of material for fusion welding.

In order that the list of A.S.T.M. specifications for steel suitable for fusion welding may be made more readily available, the subcommittee recommends that it be published in the Book of Standards. The list, appended hereto,[2] has been supplemented by additional specifications developed since it was first published in the 1930 and 1931 reports.[3]

A subgroup, working in conjunction with a committee of the American Welding Society, has developed proposed specifications for filler metal for fusion welding. At a meeting of the subcommittee in March a number of modifications in the specifications were suggested and these are now receiving the attention of the subgroup.

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[1] See pp. 533 and 539.—ED.

[2] See 1933 Book of A.S.T.M. Standards, Part I, p. 77.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 86 (1930); Vol. 31, Part I, p. 93 (1931).

Subcommittee XXII on Valves, Fittings, Piping and Flanges for High-Temperature Service (A. E. White, chairman).—Subcommittee XXII is recommending for publication as tentative the proposed Specifications for Lap-Welded and Seamless Steel Pipe for High-Temperature Service, appended hereto.[1] These specifications are in effect a revision of the present Standard Specifications A 106 – 29 and will supersede them when issued as tentative. The withdrawal of the Standard Specifications A 106 – 29 is accordingly recommended. The revised specifications were undertaken when trouble was experienced with pipe purchased under the present standard. The subcommittee has spent over a year of study and work on the revisions, including visits to several pipe mills to obtain first-hand information on methods of manufacture and commercial tests available.

The subcommittee is also recommending for immediate adoption as standard, proposed revisions in the explanatory notes of the following three standard specifications covering material for high-temperature service:

Standard Specifications for Carbon-Steel Castings for Valves, Flanges and Fittings for High-Temperature Service (A 95 – 29)
Standard Specifications for Alloy-Steel Bolting Material for High-Temperature Service (A 96 – 31)
Standard Specifications for Forged or Rolled Steel Pipe Flanges for High-Temperature Service (A 105 – 28)

The revisions in these specifications, given in detail in the Appendix, concern the use of carbon-steel piping materials at temperatures above and below 750 F. The question of allowable stresses at temperatures above 750 F. was submitted to the committee by the Sectional Committee on Standardization of Dimensions and Material of Wrought-Iron and Wrought-Steel Pipe and Tubing functioning under the procedure of the American Standards Association. Accordingly, the revisions include a pressure-temperature table to cover requirements at temperatures above and below 750 F. This subcommittee further recommends that these standard specifications as revised be submitted to the American Standards Association for approval as American Standards.

The standardization work of Committee A-1 has grown to such an extent as to entail considerable detail secretarial work. In order to relieve the Secretary of much of this detail and routine work, the committee has taken advantage of the permission granted to standing committees by the Executive Committee to employ paid assistants to handle this type of work, such assistants to be on the headquarters staff, the expenses being underwritten by the standing committees. Committee A-1 has accordingly raised the necessary funds and has had the benefit of the services of a staff assistant during the past year, which has contributed greatly in facilitating the committee's work, particularly in times such as these when so much detail must be handled by correspondence.

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[1] See p. 572.—ED.

This report has been submitted to letter ballot of the committee, which consists of 192 members; 101 members returned their ballots, of whom 98 have voted affirmatively and 2 negatively.

Respectfully submitted on behalf of the committee,

H. H. MORGAN,
Chairman.

H. P. BIGLER,
Secretary.

EDITORIAL NOTE

The proposed Tentative Specifications for Heat-Treated Steel Elliptical Springs were accepted for publication as tentative and appear on page 564. The proposed Tentative Specifications for Lap-Welded and Seamless Steel Pipe for High-Temperature Service, to supersede the existing standard specifications, and Specifications for Alloy-Steel Castings for Structural Purposes, were accepted with modifications proposed on the floor of the annual meeting, see Summary of Proceedings, pages 10 and 11, for publication as tentative and appear on pages 572 and 553, respectively. The proposed Tentative Specifications for High Tensile Strength Carbon-Steel Plates for Pressure Vessels (Plates 2 in. and Under in Thickness) and Specifications for High Tensile Strength Carbon-Steel Plates for Fusion Welded Pressure Vessels (Plates Over 2 in. Up to and Including 4 in. in Thickness), presented on the floor of the annual meeting, see Summary of Proceedings, page 11, were accepted for publication as tentative and appear on pages 533 and 539, respectively.

Revisions proposed for immediate adoption in the Standard Specifications for Structural Steel for Bridges and for Structural Steel for Buildings were approved with a modification proposed on the floor of the annual meeting, see Summary of Proceedings, page 11, by a unanimous vote at the annual meeting and were subsequently adopted by letter ballot of the Society on September 1, 1933. The specifications in their revised form appear in the 1933 Book of A.S.T.M. Standards, Part I, pages 1 and 8, respectively.

Revisions proposed for immediate adoption in the Standard Specifications for Welded and Seamless Steel Pipe, for Boiler and Firebox Steel for Locomotives, for Boiler and Firebox Steel for Stationary Service, for Commercial

Quality Hot-Rolled Bar Steels and for Commercial Cold-Finished Bar Steels and Cold-Finished Shafting, for Steel Plates of Structural Quality for Forge Welding, for Carbon-Steel Castings for Valves, Flanges and Fittings for High-Temperature Service, for Alloy-Steel Bolting Material for High-Temperature Service and for Forged or Rolled Steel Pipe Flanges for High-Temperature Service were approved at the annual meeting by a unanimous vote and were subsequently adopted by letter ballot of the Society on September 1, 1933. The specifications in their revised form appear in the 1933 Book of A.S.T.M. Standards, Part I, pages 247, 43, 48, 93, 89, 72, 259, 253, and 264, respectively.

The proposed revision of the Standard Specifications for Cold-Drawn Steel Wire for Concrete Reinforcement was accepted for publication as tentative and appears on page 1028. The proposed revision of the Tentative Specifications for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes, which specifications are being advanced to standard, with a modification proposed on the floor of the annual meeting, see Summary of Proceedings, page 12, was accepted for publication as tentative and appears on page 1028. The proposed revision of the Tentative Specifications for Normalized and Tempered Alloy-Steel Forgings for Locomotives was accepted. The specifications in their revised form appear on page 559.

The proposed revision of the Tentative Specifications for Structural Medium Steel, with a modification proposed on the floor of the annual meeting, see Summary of Proceedings, page 12, was accepted. These specifications were withdrawn subsequent to the annual meeting and replaced by new tentative specifications accepted by Committee E-10 on Standards as recorded below.

The Tentative Specifications for Soft Steel Track Spikes, for Structural Rivet Steel, for Marine Boiler Steel Plates, for Heat-Treated Carbon-Steel Helical Springs, for Austenitic Manganese-Steel Castings, as revised, and for Open-Hearth Iron Plates of Flange Quality, as revised, were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1933, and appear in the 1933 Book of A.S.T.M. Standards, Part I, pages 139, 27, 57, 161, 225, and 62, respectively. The Tentative Specifications for Steel Plates of Flange and Firebox Qualities for Forge Welding, as revised, to supersede the existing standard specifications, with a modification proposed on the floor of the annual meeting, see Summary of Proceedings, page 13; the Tentative Specifications for Structural Steel for Ships, to supersede the Standard Specifications for Structural Steel for Ships and for Rivet Steel for Ships; and the Tentative Specifications for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes, to supersede the existing standard specifications, were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1933. The specifications appear in the 1933 Book of A.S.T.M. Standards, Part I, pages 66, 36, and 240, respectively.

The tentative revisions of the Standard Specifications for Low-Carbon-Steel Splice Bars, for Quenched Carbon-Steel Track Bolts, for Quenched Alloy-Steel Track Bolts, for Steel Screw Spikes, for Low-Carbon-Steel Track Bolts, for Steel Tie Plates, for Structural Steel for Buildings, for Structural Silicon Steel, for Cold-Drawn Steel Wire for Concrete Reinforcement, for Welded and Seamless Steel Pipe, for Commercial Quality Hot-Rolled Bar Steels, and for Commercial Cold-Finished Bar Steels and Cold-Finished Shafting were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1933. The specifications in their revised form appear in the 1933 Book of A.S.T.M. Standards, Part I, pages 110, 131, 135, 108, 127, 123, 8, 30, 87, 247, 93, and 89, respectively.

The tentative revisions of the sections on process, bend tests, and test specimens of the Standard Specifications for Billet-Steel Concrete Reinforcement Bars and the Specifications for Rail-Steel Concrete Reinforcement Bars, including the addition of a new section on marking in the former specifications, were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1933. A revision proposed for immediate adoption in the sections on permissible variations in weight of concrete reinforcement as covered by these specifications, presented on the floor of the annual meeting, see Summary of Proceedings, page 14, was approved by a unanimous vote at the annual meeting and subsequently adopted by letter ballot of the Society on September 1, 1933. The specifications in their revised form appear in the 1933 Book of A.S.T.M. Standards, Part I, pages 79 and 84, respectively.

The withdrawal of the Standard Specifications for Cold-Rolled Steel Axles and for Lap-Welded and Seamless Steel Pipe for High-Temperature Service was approved.

The List of Specifications for Steel Suitable for Fusion Welding was approved for publication and appears in the 1933 Book of A.S.T.M. Standards, Part I, page 77.

Recommendations to Committee E-10 on Standards.—Subsequent to the annual meeting proposed Tentative Specifications for Carbon-Steel Castings for Industrial, Railroad and Marine Uses were presented to the society through Committee E-10 on Standards as a proposed revision and combination of the two existing standard specifications. The proposed specifications were accepted on August 16, 1933, for publication as tentative by Committee E-10 and appear on page 544.

Subsequent to the annual meeting the committee approved revisions of the Standard Specifications for Structural Steel for Bridges, Specifications for Structural Steel for Buildings and the Tentative Specifications for Structural Medium Steel in the form of new proposed Tentative Specifications for Steel for Bridges, Specifications for Steel for Buildings and Specifications for Mild Steel Plates. The three new specifications were accepted by Committee E-10 on Standards on October 30, 1933, for publication as tentative to supersede when adopted the existing standard specifications. The Tentative Specifications for Structural Medium Steel were accordingly discontinued. The three new tentative specifications appear on pages 511, 519 and 526, respectively.

APPENDIX

PROPOSED REVISIONS IN STANDARDS AND TENTATIVE STANDARDS FOR STEEL

In this Appendix are given proposed revisions in certain standard and tentative specifications covering steel and steel products. In connection with each title is given the reference to the publication in which the specifications appear in their present form.

PROPOSED REVISION OF STANDARDS

Revisions Recommended for Immediate Adoption

Standard Specifications for Structural Steel for Bridges (A 7 – 29)[1] *and for Structural Steel for Buildings (A 9 – 29):*[2]

New Section.—Add the following paragraph as a new Section 2, renumbering the present sections accordingly:

2. *Rolled Base Plates.*—Rolled base plates over 2 in. in thickness for bearing purposes, shall be open-hearth or electric-furnace steel containing 0.15 to 0.30 per cent carbon. The chemical composition shall also conform to the requirements specified in Section 4. A sufficient discard shall be made from each ingot to secure sound plates. Physical tests shall not be required for this material.

Standard Specifications for Welded and Seamless Steel Pipe (A 53 – 30):[3]

Section 5 (a).—Change the elongation requirement for open-hearth low-carbon seamless pipe from "40 per cent" to read "30 per cent" in a 2-in. gage length.

Standard Specifications for Boiler and Firebox Steel for Locomotives (A 30 – 24)[4] *and for Boiler and Firebox Steel for Stationary Service (A 70 – 27):*[5]

Section 1.—Add to the end of the scope clause in each of these specifications the phrase, "and are intended to apply to plates up to and including 2 in. in thickness."

Section 9.—The committee recommends a change in the method of making the homogeneity test for plates over $\frac{3}{4}$ in. in thickness providing also for a permissible length of any seam or cavity in these thicker plates of ⅜ in. maximum. It is accordingly recommended that this section be changed from its present form to read as follows:

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 67.

[2] *Ibid.*, p. 85.

[3] *Ibid.*, p. 245.

[4] *Ibid.*, p. 108.

[5] *Ibid.*, p. 113.

> 9. (*a*) The object of the homogeneity test, which is required for firebox steel only, is to open and render visible to the eye any seams due to failure to weld up or to interposed foreign matter, or any cavities due to gas bubbles in the ingot. The test specimen shall not show any single seam or cavity more than ¼ in. in length for plates ¾ in. and under in thickness, nor more than ⅜ in. in length for plates over ¾ in. and up to 2 in., inclusive, in thickness, in any of the fractures obtained in accordance with Paragraph (*b*). One side of each fracture shall be examined and the lengths of the seams and cavities determined, a pocket lens being used if necessary.
>
> (*b*) The test may be made on a broken tension test specimen. For plates ¾ in. and under in thickness the specimen shall be nicked or grooved transversely, in three places, about 1/16 in. deep. The first groove shall be 2 in. from the square end, and each succeeding groove on the opposite side about 2 in. from the preceding one. The specimen shall be broken at each groove in succession with a hammer or press, the bending being away from the groove. For plates over ¾ in. and up to 2 in., inclusive, in thickness, the specimen may be grooved about ⅛ in. deep at one place on one side.

Section 14.—Change the first sentence of Paragraph (*a*) to read as follows by the addition of the italicized words:

> *Except as specified in Paragraph* (*e*), the name or brand of the manufacturer, the manufacturer's test identification number, class and lowest tensile strength specified shall be legibly stamped on each finished plate in two places not less than 12 in. from the edges and on each butt strap near the center line not less than 12 in. from each end.

Change the first sentence of Paragraph (*b*) to read as follows by the addition of the italicized words and the omission of the word in brackets:

> When [specified] *designated* on the order, *except as specified in Paragraph* (*e*), plates shall be match-marked as defined in Paragraph (*c*) so that the test specimens representing them may be identified.

Add the following as a new Paragraph (*e*):

> (*e*) For plates under ¼ in. in thickness, the marking specified in Paragraphs (*a*) and (*b*) shall be legibly stenciled instead of stamped.

Standard Specifications for Commercial Quality Hot-Rolled Bar Steels (A 107 – 30):[1]

Table II.—The following proposed revisions in Table II on Permissible Variations in the Sizes of Bars are intended to harmonize the cross-sectional tolerances with those recently adopted by the Association of American Steel Manufacturers Technical Committees.

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 140.

It is recommended that Table II be changed from its present form to read as follows:

TABLE II.—PERMISSIBLE VARIATIONS IN THE SIZES OF HOT-ROLLED BARS.

Rounds and Squares					Hexagons				
Sizes Specified, in.		Variations in Size, in.			Sizes Specified Between Opposite Sides, in.		Variations in Size, in.		
Over	To and Including	Under	Over	Out of Round or Square	Over	To and Including	Under	Over	Difference Three Measurements
...	$\frac{5}{16}$	0.007	0.007	0.010	...	$\frac{1}{2}$	0.007	0.007	0.011
$\frac{5}{16}$	$\frac{7}{16}$	0.007	0.007	0.011	$\frac{1}{2}$	1	0.010	0.010	0.015
$\frac{7}{16}$	$\frac{5}{8}$	0.008	0.008	0.012	1	$1\frac{1}{2}$	0.013	0.021	0.025
$\frac{5}{8}$	$\frac{7}{8}$	0.009	0.009	0.014	$1\frac{1}{2}$	2	$\frac{1}{64}$	$\frac{1}{32}$	$\frac{1}{32}$
$\frac{7}{8}$	1	0.010	0.010	0.015	2	$2\frac{1}{2}$	$\frac{1}{64}$	$\frac{3}{64}$	$\frac{3}{64}$
1	$1\frac{1}{8}$	0.012	0.012	0.016	$2\frac{1}{2}$	$3\frac{1}{2}$	$\frac{1}{64}$	$\frac{1}{16}$	$\frac{1}{16}$
$1\frac{1}{8}$	$1\frac{1}{4}$	0.014	0.014	0.018					
$1\frac{1}{4}$	$1\frac{3}{8}$	0.016	0.016	0.022					
$1\frac{3}{8}$	$1\frac{1}{2}$	0.018	0.018	0.026					
$1\frac{1}{2}$	2	0.022	0.022	0.030					
2	$2\frac{1}{2}$	0	$\frac{1}{16}$	$\frac{1}{32}$					
$2\frac{1}{2}$	$3\frac{1}{2}$	0	$\frac{5}{64}$	$\frac{3}{64}$					
$3\frac{1}{2}$	$4\frac{1}{2}$	0	$\frac{3}{32}$	$\frac{1}{16}$					
$4\frac{1}{2}$	$5\frac{1}{2}$	0	$\frac{7}{64}$	$\frac{5}{64}$					
$5\frac{1}{2}$	8	0	$\frac{1}{8}$	$\frac{3}{32}$					

FLATS, SQUARE-EDGE AND ROUND-EDGE

Width of Flats Specified, in.		Variations in Width, in.		Variations in Thickness, Under or Over, in., for Thickness Specified			
Over	To and Including	Under	Over	$\frac{3}{16}$ or Under	Over $\frac{3}{16}$ to $\frac{1}{2}$, incl.	Over $\frac{1}{2}$ to 1, incl.	Over 1 to 2, incl.
..	1	$\frac{1}{64}$	$\frac{1}{64}$	0.006	0.008	0.010	....
1	2	$\frac{1}{32}$	$\frac{1}{32}$	0.008	0.012	0.015	$\frac{1}{32}$
2	4	$\frac{1}{32}$	$\frac{1}{16}$	0.010	0.015	0.020	$\frac{1}{32}$
4	6	$\frac{1}{16}$	$\frac{3}{32}$	0.010	0.015	0.020	$\frac{1}{32}$

Standard Specifications for Commercial Cold-Finished Bar Steels and Cold-Finished Shafting (A 108 – 30):[1]

Section 1 (*b*).—Change to read as follows by the addition of the italicized words and figure and the omission of those in brackets:

> (*b*) The sections of bar steel covered are rounds, squares and hexagons of all sizes, and flats not over 6 in. [wide] *in width.* The sections of shafting covered are rounds up to [6] *8* in., inclusive.

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 144.

Section 7.—Change from its present form: namely,

7. (*a*) The variation from the specified diameters, or distances between parallel faces, of cold-finished bars specified in carbon up to and including 0.30 per cent, shall not exceed the limits specified in Table III. For bars specified in carbon over 0.30 per cent, the variations shall be a matter of agreement between the purchaser and the manufacturer.

(*b*) The variations from the specified diameters of cold-finished shafting shall not exceed the limits specified in Table IV.

to read as follows:

7. The variation from the specified diameters of cold-finished round bars or shafting, and distances between parallel faces of hexagons, squares or flats, shall not exceed the limits specified in Table III.

Tables III and IV.—The revision of these tables is intended to make the cross-sectional tolerances in accordance with those adopted by the Cold-Finished Steel Bar Institute. It is recommended that the accompanying Table III be inserted in place of the present Tables III and IV, which are to be omitted.

Standard Specifications for Steel Plates of Structural Quality for Forge Welding (A 78 – 30):[1]

Section 3 (b).—A further change is recommended in the tentative revision of this section proposed last year, pertaining to the chemical composition when the material is used for fusion welding. It is accordingly proposed to change the Note from the form as recommended last year: namely,

NOTE.—When these specifications are used for material to be fusion welded the maximum limit for nickel shall not apply, and the maximum limit for silicon shall be 0.10 per cent. In cases where fusion welding is done by special processes, or with the use of fluxes, steel with higher silicon and/or chromium contents has been successfully welded. It is suggested that in such cases the chromium and silicon desired be agreed upon by the purchaser and manufacturer.

to read as follows:

NOTE.—When these specifications are used for material that is to be fusion welded, the maximum limits specified for silicon, nickel, and chromium shall not apply. Soft steel within the carbon limits specified will normally not contain those elements in sufficient amounts to be detrimental for fusion welding purposes. When special limits are required for fusion welding they shall be specified by the purchaser. He shall also specify whether material is to be used for forge or fusion welding.

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 122.

TABLE III.—PERMISSIBLE VARIATIONS IN THE SIZES OF COLD-FINISHED BARS AND SHAFTING.

	Variations in Size, in.			
	Carbon 0.30 per cent and less		Carbon 0.31 to 0.50 per cent	
	Under	Over	Under	Over
ROUND BARS, SHAFTING				
Specified Diameters				
Up to 1 in., inclusive	0.002	0	0.003	0
Over 1 to 2 " "	0.003	0	0.004	0
" 2 to 4 " "	0.004	0	0.005	0
" 4 to 6 " "	0.005	0	0.006	0
" 6 to 8 " "	0.006	0	0.008	0
HEXAGONS				
Specified Dimensions Between Opposite Sides				
Up to 0.3 in., inclusive	0.002	0	0.003	0
Over 0.3 to 1 " "	0.003	0	0.004	0
" 1 to 2½ " "	0.004	0	0.005	0
" 2½ to 4 " "	0.005	0	0.006	0
SQUARES				
Specified Dimensions				
Up to 0.3 in., inclusive	0.003	0	0.004	0
Over 0.3 to 1 " "	0.004	0	0.005	0
" 1 to 2½ " "	0.005	0	0.006	0
" 2½ to 4 " "	0.006	0	0.008	0

FLATS

Specified Thicknesses	Variations in Width and/or Thickness, in.					
	For Widths Less than 1½ in.		For Widths 1½ to 4 in., inclusive		For Widths Over 4 to 6 in.	
	Under	Over	Under	Over	Under	Over
CARBON 0.30 PER CENT AND LESS						
Up to 0.3 in., inclusive	0.003	0	0.005	0	0.008	0
Over 0.3 to 1 " "	0.004	0	0.005	0	0.009	0
" 1 to 2½ " "	0.005	0	0.006	0	0.010	0
CARBON 0.31 TO 0.50 PER CENT						
Up to 0.3 in., inclusive	0.004	0	0.006	0	0.010	0
Over 0.3 to 1 " "	0.005	0	0.006	0	0.012	0
" 1 to 2½ " "	0.006	0	0.008	0	0.012	0

Standard Specifications for Carbon-Steel Castings for Valves, Flanges and Fittings for High-Temperature Service (A 95 - 29),[1] *for Alloy-Steel Bolting Material for High-Temperature Service (A 96 - 31),*[2] *and for Forged or Rolled Steel Pipe Flanges for High-Temperature Service (A 105 - 28):*[3]

Explanatory Note.—Change the Note appearing at the end of Specifications A 95 and A 96 and Note 1 of Specifications A 105 from the present form: namely,

NOTE.—This contemplates temperatures up to 750 F. (400 C.); or at the discretion of the designing engineer higher temperatures with appropriate pressures may be used. Reference may be made to the dimensional standards for pressures and temperatures formulated by the Sectional Committee on Standardization of Pipe Flanges and Fittings under the procedure of the American Standards Association, A.S.A. Project No. B 16 and more specifically to the American Steel Pipe Flanges and Flanged Fittings Standard B 16*e* - 1927. Copies of this American Standard are obtainable from the American Standards Association or from the American Society of Mechanical Engineers, 29 West 39th St., New York City.

to read as follows:

NOTE.—This contemplates temperatures from 500 to 850 F. Allowable pressures and their corresponding allowable temperatures are given in the following table. Higher temperatures with appropriate pressures may be used at the discretion of the designing engineer.

TABLE I.—ADJUSTED SERVICE PRESSURES FOR POWER PIPING AT TEMPERATURES BELOW AND ABOVE 750 F.

Steam Service Pressure Rating at 750 F., lb. per sq. in.	100	300	400	600	900	1500
SERVICE TEMPERATURE, DEG. FAHR.	ADJUSTED SERVICE PRESSURES, LB. PER SQ. IN.					
500	150	370	500	720	1080	1800
550	120	360	480	720	1080	1800
600	115	350	460	700	1040	1740
650	110	330	440	670	1000	1660
700	105	315	420	630	950	1580
750	100	300	400	600	900	1500
800	85	250	325	500	750	1250
850	70	200	270	400	600	1000

Reference may be made to the dimensional standards for hydraulic pressure ratings and corresponding temperatures formulated by the Sectional Committee on Standardization of Pipe Flanges and Fittings, under the procedure of the American Standards Association, A.S.A. Project B 16 and more specifically to the American Standard for Steel Flanged Fittings and Companion Flanges, B 16*e* - 1932. Copies of this American Standard are obtainable from the American Standards Association or from the American Society of Mechanical Engineers, 29 West 39th St., New York City.

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 264.

[2] 1931 Supplement to Book of A.S.T.M. Standards, p. 9.

[3] 1930 Book of A.S.T.M. Standards, Part I, p. 274.

Standard Specifications for Billet-Steel Concrete Reinforcement Bars (A 15 – 30) and for Rail-Steel Concrete Reinforcement Bars (A 16 – 14):[1]

Permissible Variations in Weight.—Change Section 13 of Specifications A 15 and Section 9 of Specifications A 16 from their present form: namely,

> The weight of any lot of bars shall not vary more than 5 per cent from the theoretical weight of that lot.

to read as follows:

> The weight of any lot of bars shall not vary more than 3½ per cent over or under the theoretical weight for bars ⅜ in. and over in diameter nor more than 5 per cent over or under for bars under ⅜ in. in diameter. The theoretical weight of deformed bars shall be the theoretical weight of plain round or square bars of the same nominal size. The term "lot" used in this paragraph means all the bars of the same nominal weight per linear foot in a carload.

Revision Recommended for Publication as Tentative

Standard Specifications for Cold-Drawn Steel Wire for Concrete Reinforcement (A 82 – 27):[2]

Section 4.—Change the table of minimum requirements appearing in Paragraph (*a*) to read as follows by the addition of the italicized words and figures:

Tensile strength, lb. per sq. in.	80 000
Yield point, per cent of observed tensile strength	*80*
Reduction of area, per cent	30

Add the following as a new Paragraph (*c*), relettering the present Paragraph (*c*) as Paragraph (*d*):

> (*c*) The yield point shall be determined by the drop of the beam or halt in the gage of the testing machine. In case no definite drop of the beam or halt in the gage is observed until final rupture occurs, the test shall be construed as meeting the requirement for yield point in Paragraph (*a*).

Section 8.—Change this section from its present form: namely,

> 8. The diameter of the wire shall not vary more than 0.003 in. from the size ordered.

to read as follows:

> 8. The dimensions of the wire, on any diameter, shall not vary more than 0.003 in. from the specified nominal diameter. The difference between the maximum and minimum diameters, as measured on any given cross-section of the wire, shall not be greater than 0.003 in.

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[1] 1930 Book of A.S.T.M. Standards, Part I, pp. 131 and 135.

[2] *Ibid.*, p. 138.

PROPOSED REVISION OF TENTATIVE STANDARDS

Tentative Specifications for Austenitic Manganese-Steel Castings (A 128 - 30 T):[1]

Section 4.—It is recommended that the table of chemical requirements be modified by changing the present range in manganese content from "10.00 to 14.00 per cent" to read "not under 10 per cent" and by adding a requirement for sulfur of "not over 0.05 per cent."

Tentative Specifications for Open-Hearth Iron Plates of Flange Quality (A 129 - 30 T):[2]

Section 13.—Change the first sentence of Paragraph (*a*) to read as follows by the addition of the italicized words:

> *Except as specified in Paragraph* (*e*), the name or brand of the manufacturer, the manufacturer's test identification number, and tensile strength specified in Section 6 (*a*) shall be legibly stamped on each plate.

Change the first sentence of Paragraph (*b*) to read as follows by the addition of the italicized words and the omission of the word in brackets:

> When [specified] *designated* on the order, *except as specified in Paragraph* (*e*), plates shall be match-marked as defined in Paragraph (*c*) so that the test specimens representing them may be identified.

Add the following as a new Paragraph (*e*):

> (*e*) For plates under ¼ in. in thickness, the marking specified in Paragraphs (*a*) and (*b*) shall be legibly stenciled instead of stamped.

Tentative Specifications for Steel Plates of Flange and Firebox Qualities for Forge Welding (A 89 - 32 T):[3]

Section 3 (*b*).—Change the Note following this section from its present form: namely,

> NOTE.—When these specifications are used for material to be fusion welded the maximum limit for nickel shall not apply and the maximum limit for silicon shall be 0.10 per cent. In cases where fusion welding is done by special processes, or with the use of fluxes, steel with higher silicon and/or chromium contents has been successfully welded. It is suggested that in such cases the chromium and silicon desired be agreed upon by the purchaser and manufacturer.

to read as follows:

> NOTE.—When these specifications are used for material that is to be fusion welded, the maximum limits specified for silicon, nickel, and chromium shall

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 969 (1930); also 1932 Book of A.S.T.M Tentative Standards, p. 94.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 965 (1930); also 1932 Book of A.S.T.M. Tentative Standards, p. 46.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 543 (1932); also 1932 Book of A.S.T.M. Tentative Standards, p. 55.

not apply. Soft steel within the carbon limits specified will normally not contain those elements in sufficient amounts to be detrimental for fusion welding purposes. When special limits are required for fusion welding they shall be specified by the purchaser. He shall also specify whether material is to be used for forge or fusion welding.

Section 9.—Change this section from its present form to read as follows:

9. (*a*) The object of the homogeneity test, which is required for firebox steel only, is to open and render visible to the eye any seams due to failure to weld up or to interposed foreign matter, or any cavities due to gas bubbles in the ingot. The fractured surface of the test specimen shall not show any single seam or cavity more than ¼ in. in length for plates ¾ in. and under in thickness, more than ⅜ in. in length for plates over ¾ to 4 in., inclusive, nor more than ½ in. in length for plates over 4 to 6 in., inclusive, in any of the fractures obtained in accordance with Paragraph (*b*). One side of each fracture shall be examined and the lengths of the seams and cavities determined, a pocket lens being used if necessary.

(*b*) The test may be made on a broken tension test specimen when an 8-in. gage length specimen is used. When a 2-in. gage length tension test specimen is used, the specimen for homogeneity test shall be taken adjacent, sidewise or lengthwise, to the top tension test specimen. For plates ¾ in. and under in thickness the specimen shall be nicked or grooved transversely, in three places, about 1/16 in. deep. The first groove shall be 2 in. from the square end, and each succeeding groove on the opposite side about 2 in. from the preceding one. The specimen shall be broken at each groove in succession with a hammer or press, the bending being away from the groove. For plates over ¾ in. and up to 2⅛ in., inclusive, in thickness the specimen may be grooved about ⅛ in. deep, at one place on one side. For plates over 2⅛ in. in thickness the specimen may be grooved at one place on both sides to leave a fracture which will include the horizontal axis of the plate and have a face at least 2 in. in depth.

Section 14.—Change the first sentence of Paragraph (*a*) to read as follows by the addition of the italicized words:

Except as specified in Paragraph (*e*), the name or brand of the manufacturer, the manufacturer's test identification number, class, and lowest tensile strength for the grade specified in Section 6 (*a*) shall be legibly stamped on each plate.

Change the first sentence of Paragraph (*b*) to read as follows by the addition of the italicized words and the omission of the word in brackets:

When [specified] *designated* on the order, *except as specified in Paragraph* (*e*), plates shall be match-marked as defined in Paragraph (*c*) so that the test specimens representing them may be identified.

Add the following as a new Paragraph (*e*):

(*e*) For plates under ¼ in. in thickness, the marking specified in Paragraphs (*a*) and (*b*) shall be legibly stenciled instead of stamped.

Tentative Specifications for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83 – 32 T):[1]

Section 17.—Change this section from its present form: namely,

> **17. The name or brand of the manufacturer, the grade of material from which it is made, whether lap-welded steel or iron, and the hydrostatic pressure in pounds at which it was tested shall be legibly stenciled on each tube.**

to read as follows:

> 17. (*a*) The name or brand of the manufacturer, the grade of material from which it is made, whether seamless or lap-welded, and whether steel or iron, together with the hydrostatic pressure in pounds at which it was tested, shall be legibly stenciled on each tube 1¼ in. in outside diameter and over, provided the length is not under 3 ft.
>
> (*b*) On tubes less than 1¼ in. in diameter and on all tubes under 3 ft. in length, the name or initials or brand of the manufacturer shall be legibly stenciled or indicated on a sticker applied on each tube.

Tentative Specifications for Normalized and Tempered Alloy-Steel Forgings for Locomotives (A 133 – 31 T):[2]

Section 10 (a).—It is recommended that the table of tensile properties be modified by changing the yield point requirement for Class A material from "0.67 tens. str." to read, "55 000 lb. per sq. in.," and for Class B material from "0.62 tens. str." to read "58 000 lb. per sq. in."

Tentative Specifications for Structural Medium Steel (A 140 – 32 T):[3]

New Section.—Add the following paragraph as a new Section 2, renumbering the present sections accordingly:

> 2. *Rolled Base Plates.*—Rolled base plates over 2 in. in thickness for bearing purposes shall be open-hearth or electric-furnace steel containing 0.20 to 0.35 per cent carbon. The chemical composition shall also conform to the requirements specified in Section 4. A sufficient discard shall be made from each ingot to secure sound plates. Physical tests shall not be required for this material.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 549 (1932); also 1932 Book of A.S.T.M. Tentative Standards, p. 98.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 668 (1931); also 1932 Book of A.S.T.M. Tentative Standards, p. 79.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 534 (1932); also 1932 Book of A.S.T.M. Tentative Standards, p. 30.

REPORT OF SECTIONAL COMMITTEE ON STANDARDIZATION OF DIMENSIONS AND MATERIAL OF WROUGHT-IRON AND WROUGHT-STEEL PIPE AND TUBING

The Sectional Committee on Standardization of Wrought-Iron and Wrought-Steel Pipe and Tubing has not held a meeting since that of June, 1932, which was convened in connection with the annual meeting of the American Society for Testing Materials. A joint meeting of Subcommittees 2 and 3 on Pipe and Tubing for Low- and High-Temperature Service, respectively, was held in connection with the regional meeting in New York City in March, 1933.

The most important item under consideration in the sectional committee is the proposed American Tentative Standard for Wrought-Iron and Wrought-Steel Pipe. This proposed standard was developed to meet present widely different and increasingly severe service conditions which were not visualized when the existing standard dimensions were originally published in 1886. The proposed standard covers pipe manufactured from a variety of materials including wrought iron, and carbon and alloy steels; manufactured by many processes including furnace welding, seamless, electric-fusion and resistance welding; and intended for a number of types of end connection including threaded, welded, van stoned, etc. The standard covers the entire field of piping work for wrought-iron and wrought-steel pipe from the lowest pressure requiring the use of thin-walled pipe in the larger sizes to pipe sufficiently heavy for the highest pressure standard now in use, that for 1500 lb.

In the development of the tentative standard which has resulted from the activities of the sectional committee, it was obvious that with the variety of materials available for piping use, pipe-wall-thickness schedules, to be flexible, could not be computed for any particular temperature, pressure, or material. For this reason, schedules were based on P/S values, where P represents the service pressure and S the value of allowable stress. Since the latter is dependent on the material and service temperature contemplated, all three variables were considered. The thicknesses of the present standard-weight and extra-strong pipe have also been included in the proposed standard because of the large quantities in use and the familiarity of the trade with them.

It is intended that this standard shall be employed in conjunction with the application of the Code for Pressure Piping now being developed by the sectional committee having the same name (B 31). From the Code for Pressure Piping, the required minimum thickness on inspection may be computed and from the proposed pipe standard, the corresponding available commercial thickness may be selected. It should be recognized, however, that the proposed pipe standard is not concerned primarily with determination of the minimum pipe-wall thickness for any specific set of working conditions and does not attempt to influence design. It is contemplated that this standard for pipe will cover the requirements of all industries. Special thicknesses no doubt will be required for unusual application, but the schedules of pipe proposed in this standard are intended to simplify stocks so that pipe to these wall thicknesses may be readily available throughout the country.

The proposed standard has been published and over 300 copies sent out to industry for comment. At the joint meeting of Subcommittees 2 and 3 held in March, the comments received were considered and the tentative draft revised where necessary. It is contemplated that the proposed standard will be presented to the sectional committee for approval at the annual meeting of the Society.

Since the proposed pipe standard includes detailed information concerning many A.S.T.M. specifications on pipe, the sectional committee deemed it advisable that the following A.S.T.M. pipe specifications be approved individually by the American Standards Association:

Standard Specifications for Welded and Seamless Steel Pipe (A 53 – 30);
Standard Specifications for Welded Wrought-Iron Pipe (A 72 – 31);
Standard Specifications for Lap-Welded and Seamless Steel Pipe for High-Temperature Service (A 106 – 29);
Tentative Specifications for Electric-Resistance-Welded Steel Pipe (A 135 – 32 T);
Tentative Specifications for Forge-Welded Steel Pipe (A 136 – 32 T);
Tentative Specifications for Lock-Bar Steel Pipe (A 137 – 32 T);
Tentative Specifications for Riveted Steel and Wrought-Iron Pipe (A 138 – 32 T);
Tentative Specifications for Electric-Fusion-Welded Steel Pipe (Sizes 30 in. and Over) (A 134 – 32 T);
Tentative Specifications for Electric-Fusion-Welded Steel Pipe (Sizes 8 in. to but not Including 30 in.) (A 139 – 32 T).

A.S.T.M. specifications which are now listed as tentative were submitted for approval to the A.S.A. as American Tentative Standards. Tentative specifications which are advanced to standard will likewise be changed from American Tentative Standards to American

Standards, and any elimination of A.S.T.M. specifications will be followed by an elimination of the corresponding American Standard.

This matter was submitted to letter ballot of the sectional committee with the following result: Affirmative, 32; negative, 1; not voting, 7; total 40.

A reduction in the mill tolerance on wall thickness of pipe was considered, especially for welded pipe. It was the consensus of the pipe-manufacturing interests of the sectional committee that this tolerance should not be reduced below the 12½ per cent which is now accepted.

Subcommittee 3 on Pipe for High-Temperature Service has under consideration the revision of Table I of the Standard Specifications for Lap-Welded and Seamless Steel Pipe for High-Temperature Service (A 106 - 29). The revised table, when available, will conform to the proposed standard on pipe formulated by the sectional committee.

Respectfully submitted on behalf of the sectional committee,

H. H. MORGAN,
Chairman.

SABIN CROCKER,
Secretary.

REPORT OF COMMITTEE A-2

ON

WROUGHT IRON

Committee A-2 on Wrought Iron has held one meeting this year at New York City on March 7, 1933. A second meeting will be held prior to the presentation of this report to the Society when the report will be reviewed and other matters considered.

It is with regret that the committee announces the deaths of the following members: Mr. J. A. Burden, Burden Iron Co.; Mr. C. M. Walsh, Falls Hollow Staybolt Co.; Mr. L. E. Frazier, American Chain Co.; and Mr. F. O. Kichline, Bethlehem Steel Co.

The resignation during the year of the following members of Committee A-2 is announced with regret: Mr. W. A. Hicks, Penn Iron and Steel Co.; Mr. P. E. Miller, The Tredegar Co.; and Mr. J. K. Aimer, Reading Iron Co.

RECOMMENDATIONS AFFECTING STANDARDS

The recommendations of the committee affecting standards are presented first in summarized form, together with an analysis of the letter ballot on each item. They are then further referred to under subcommittee activities, being grouped for convenience in the order of the respective subcommittees responsible for them.

I. Proposed Tentative Standard.—The committee recommends that the proposed Tentative Specifications for Wrought-Iron Rivets and Rivet Rounds, prepared by Subcommittee III, as appended hereto,[1] be accepted for publication as tentative.

II. Proposed Revision of Standards.—The committee recommends that the revisions in the following three standards as proposed in the reports of the subcommittees be immediately adopted as standard. The committee accordingly asks for the necessary nine-tenths vote at the annual meeting in order that these revisions may be submitted to letter ballot of the Society for immediate adoption.

Standard Specifications for Welded Wrought-Iron Pipe (A 72 - 31), revised immediately as proposed by Subcommittee I;

Standard Specifications for Staybolt, Engine-Bolt and Extra-Refined Wrought-Iron Bars (A 84 - 30), revised immediately as proposed by Subcommittee III;

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[1] See p. 587.—Ed.

Standard Definitions of Terms Relating to Wrought Iron Specifications (A 81 – 30), revised immediately as proposed by Subcommittee VII.

III. Advancement of Tentative Revision of Standards to Standard.—The committee recommends that the tentative revisions[1] proposed a year or two ago in the following standards[2] be advanced to standard:

Revision of Standard Specifications for Staybolt, Engine-Bolt and Extra-Refined Wrought-Iron Bars (A 84 – 30), as proposed by Subcommittee III; and

Revision of Standard Definitions of Terms Relating to Wrought Iron Specifications (A 81 – 30), as proposed by Subcommittee VII.

The recommendations appearing in this report have been submitted to letter ballot of the committee, which consists of 53 members, with the following results:

Items	Affirmative	Negative	Not Voting
I. PROPOSED TENTATIVE STANDARD			
Specifications for Wrought-Iron Rivets and Rivet Rounds[a]	38	4	3
II. PROPOSED REVISION OF STANDARDS			
Specifications for Welded Wrought-Iron Pipe (A 72 – 31), immediate adoption	41	1	3
Specifications for Staybolt, Engine-Bolt and Extra-Refined Wrought-Iron Bars (A 84 – 30), immediate adoption	43	0	2
Definitions of Terms Relating to Wrought Iron Specifications (A 81 – 30), immediate adoption	39	1	5
III. ADVANCEMENT OF TENTATIVE REVISION OF STANDARDS TO STANDARD			
Specifications for Staybolt, Engine-Bolt and Extra-Refined Wrought-Iron Bars (A 84 – 30)	43	0	2
Definitions of Terms Relating to Wrought Iron Specifications (A 81 – 30)	41	0	4
IV. PROPOSED REVISION OF TENTATIVE STANDARDS			
Specifications for Electric Fusion Welded Steel Pipe (A 134 – 32 T)	32	1	12
Specifications for Electric Fusion Welded Steel Pipe (A 139 – 32 T)	32	1	12
Specifications for Electric Resistance Welded Steel Pipe (A 135 – 32 T)	32	1	12
Specifications for Forge Welded Steel Pipe (A 136 – 32 T)	32	1	12
Specifications for Lock Bar Steel Pipe (A 137 – 32 T)	32	0	13

[a] The classified vote on the Tentative Specifications for Wrought-Iron Rivets and Rivet Rounds was as follows: Affirmative: 12 producers, 20 consumers, 6 general interests; negative: 2 producers, 1 consumer, 1 general interest; not voting: 2 producers and 1 consumer.

ACTIVITIES OF SUBCOMMITTEES

Subcommittee I on Tubes and Pipe (G. H. Woodroffe, chairman).—Subcommittee I has prepared a number of proposed revisions in five tentative specifications covering as many types of fabricated steel pipe. These revisions were presented to Committee A-2 at the March meeting. As these pipe specifications are under the jurisdiction of Committee A-1 on Steel the revisions will be submitted to that committee upon approval by letter ballot of Committee A-2. The results of the letter ballot are given in the above table.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, pp. 981, 986 (1932); also 1932 Book of A.S.T.M. Tentative Standards, pp. 1125, 1130.

[2] 1930 Book of A.S.T.M. Standards, Part I, p. 435, 464.

This subcommittee is recommending for immediate adoption the following revision in the Standard Specifications for Welded Wrought-Iron Pipe (A 72 – 31):[1]

Chemical Composition.—Add as a new Section 4 the following requirement for chemical composition, renumbering the present Section 4 and the subsequent sections accordingly:

> 4. Chemical Composition.—The iron shall conform to the following requirement as to chemical composition:
>
> Manganese, max., per cent............................ 0.05

Subcommittee III on Staybolt and Engine-Bolt Iron (E. J. Edwards, chairman).—This subcommittee is presenting for publication as tentative proposed Tentative Specifications for Wrought-Iron Rivets and Rivet Rounds, appended hereto.[2] The growing demand for large diameter pipe, tanks and other structures fabricated from wrought-iron plates by riveting or welding has shown the necessity of a specification for wrought-iron rivets. The need for such specifications was first brought to the attention of Committee A-2 in connection with the proposal to include provisions for wrought iron in the Tentative Specifications for Riveted Steel and Wrought-Iron Pipe (A 138 – 32 T). The proposed Tentative Specifications for Wrought-Iron Rivets and Rivet Rounds[2] are the result of the apparent demand for such a specification.

At its meeting in March, Subcommittee III recommended the advancement to standard of the tentative revisions proposed in 1931[3] of the Standard Specifications for Staybolt, Engine-Bolt and Extra-Refined Wrought-Iron Bars (A 84 – 30).[4]

This subcommittee also recommended, as given in detail below, a revision for immediate adoption in the Standard Specifications A 84 to provide physical requirements for bars $\frac{3}{16}$ in. or less in thickness ordered to the new grade B_1 of these specifications:

Section 6 (a).—Insert in this section the following physical requirements:

> Flat bars having a thickness $\frac{3}{16}$ in. or less shall conform to the following minimum requirements as to tensile properties:

Tensile strength, lb. per sq. in.	47 000
Yield point, lb. per sq. in.	0.6 tens. str.
Elongation in 8 in., per cent	22
Reduction of area, per cent	30

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[1] 1931 Supplement to Book of A.S.T.M. Standards, p. 14.

[2] See p. 587.—ED.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, pp. 142, 1043 (1931); also 1932 Book of A.S.T.M. Tentative Standards, p. 1125.

[4] 1930 Book of A.S.T.M. Standards, Part I, p. 435.

Subcommittee IV on Plates, Shapes and Sheets (James Aston, chairman).—This subcommittee has developed a complete revision of the Standard Specifications for Wrought-Iron Plates (A 42 - 30).[1] The principal features of the revised specifications will be (*a*) the elimination of plates of any quality not conforming to standard definition of wrought iron, (*b*) revision of physical properties to recognize that by appropriate rolling practice the transverse physical properties of wrought-iron plates may be increased, with, however, a proportionate reduction in the longitudinal properties, this relation is covered by a formula, (*c*) defining the scope to include bending or similar fabricating requirements, and (*d*) insertion of thickness and weight tolerance limits. As soon as the revised specifications are approved by the subcommittee they will be submitted to Committee A-2 as a proposed revision of the present standard.

Subcommittee V on Chain Iron and Iron Chain (F. M. Waring, chairman).—This subcommittee has under consideration a proposal received from a number of independent chain manufacturers to revise the Standard Specifications for Iron and Steel Chain (A 56 - 30) to include requirements for a strictly hand-made chain. However, the subcommittee has no recommendations to make at this time.

Subcommittee VII on Nomenclature and Definitions (J. B. Young, chairman).—This subcommittee is recommending the advancement to standard of the following revised definition for double-refined iron, proposed as a tentative revision in 1931 to replace the present definition appearing in the Standard Definitions of Terms Relating to Wrought Iron Specifications (A 81 - 30):[2]

> *Double-Refined Iron.*—Iron to be classed as double refined shall be all new wrought iron,[a] which shall be first rolled into muck bars. These bars shall then be twice piled and rerolled. All iron shall be free from steel and from foreign scrap. The manufacturer may use his own mill products of at least equal quality, but only in the first piling. In the final piling all bars shall be of the full length of the pile.

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[a] Wrought Iron is defined as follows in the Standard Definitions of Terms Relating to Wrought Iron Specifications (A.S.T.M. Designation: A 81) of the American Society for Testing Materials:

Wrought Iron.—A ferrous material, aggregated from a solidifying mass of pasty particles of highly refined metallic iron with which, without subsequent fusion, is incorporated a minutely and uniformly distributed quantity of slag.

The subcommittee is also recommending for immediate adoption the following revision of the definition of muck bar appearing in the present Standard Definitions A 81:

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 452.

[2] *Ibid.*, p. 464.

Muck Bar.—Change to read as follows by the addition of the italicized words and the omission of the words in brackets:

> Muck Bar [or Puddled Bar].—Bar rolled from [puddled balls, made wholly from puddled pig iron] *a squeezed bloom.*

Subcommittee X on Research (J. H. Higgins, chairman).—This subcommittee has been attempting a correlation of data and the preparation of a brochure on Quality Standards for Wrought Iron. Mr. James Aston, in charge of the work, reports that few replies have been received to the questionnaire sent out last spring. The first draft of the brochure is in process of preparation and will receive consideration during the current year.

This report has been submitted to letter ballot of the committee, which consists of 53 members; 43 members returned their ballots, of whom 42 have voted affirmatively and 1 negatively.

Respectfully submitted on behalf of the committee,

H. W. FAUS,
Chairman.

G. H. WOODROFFE,
Secretary.

EDITORIAL NOTE

The proposed Tentative Specifications for Wrought-Iron Rivets and Rivet Rounds were accepted for publication as tentative and appear on page 587.

Revisions proposed for immediate adoption in the Standard Specifications for Welded Wrought-Iron Pipe, for Staybolt, Engine-Bolt and Extra-Refined Wrought-Iron Bars and in the definition of the term muck bar, appearing in the Standard Definitions of Terms Relating to Wrought Iron Specifications, were approved at the annual meeting by a unanimous vote and were subsequently adopted by letter ballot of the Society on September 1, 1933. The standards in their revised form appear in the 1933 Book of A.S.T.M. Standards, Part I, pages 454, 437, and 462, respectively.

The tentative revisions of the Standard Specifications for Staybolt, Engine-Bolt and Extra-Refined Wrought-Iron Bars and the revised definition of the term double-refined iron, appearing in the Standard Definitions of Terms Relating to Wrought Iron Specifications, were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1933. The standards in their revised form appear in the 1933 Book of A.S.T.M. Standards, Part I, pages 437 and 462, respectively.

REPORT OF COMMITTEE A-3
ON
CAST IRON

Since the 1932 annual meeting of the Society, Committee A-3 on Cast Iron held one meeting at New York City on March 7, 1933. A second meeting will be held prior to the presentation of this report to the Society, at which time the report will be reviewed and other matters will be considered.

At the March, 1932, meeting of the committee, it was decided to cooperate with the American Foundrymen's Association in the presentation of a comprehensive symposium on gray-iron castings at the 1933 annual meeting of the American Society for Testing Materials at Chicago, Ill. A joint committee was appointed and the material for the symposium has been assembled. Mr. R. E. Kennedy, Technical Secretary of the A.F.A., has acted as secretary of the joint committee and Mr. H. Bornstein as chairman.

At the May, 1932, meeting of Committee A-3 it was decided to cooperate with the American Foundrymen's Association in the preparation of a program covering discussion of specifications and testing methods for cast iron to be presented at the 1933 meeting of the American Foundrymen's Association. A joint committee was appointed and the program will be presented at the meeting of the American Foundrymen's Association to be held at Chicago on June 23, 1933.

The most important investigation ever sponsored by Committee A-3 was that on impact testing of cast iron which has been under the direction of Subcommittee XV on Impact Testing (J. T. MacKenzie, chairman). Funds for this investigation were raised in the membership of Committee A-3, and various members and nonmembers cooperated in carrying on the work. The U. S. Bureau of Standards rendered valuable assistance.

The report on impact testing which is appended to this report contains what is probably the most comprehensive series of data on the physical properties of cast iron ever assembled in this country. This investigation has been made possible largely through the efforts of the chairman of Subcommittee XV and the committee desires to express its most sincere appreciation to Mr. J. T. MacKenzie and to the American Cast Iron Pipe Co. for this contribution.

The present membership of the committee is 95, of whom 33 are classified as producers, 42 as consumers, and 20 as general interest members.

RECOMMENDATIONS AFFECTING STANDARDS

Advancement of Tentative Standard to Standard.—Tentative Specifications for Gray-Iron Castings (A 48 – 32 T)[1] were issued as tentative in 1932. These specifications have been well received by the industry during the past year and have practically superseded the present Standard Specifications for Gray-Iron Castings (A 48 – 29)[2] and the Standard Specifications for High-Test Gray-Iron Castings (A 88 – 31).[3] The committee accordingly recommends the withdrawal of these two standard specifications and the continuation as tentative of Specifications A 48 – 32 T. This recommendation has been referred to letter ballot of the committee, which consists of 95 members, with the following results from a total of 59 ballots returned: Specifications A 48, 47 affirmative, 1 negative, 11 not voting; Specifications A 88, 46 affirmative, 0 negative and 13 not voting.

ACTIVITIES OF SUBCOMMITTEES

Subcommittee I on Pig Iron (C. D. Mathews, chairman).—This subcommittee, which has been inactive for a number of years, has been reorganized under its new chairman and is working on the development of pig iron specifications.

Subcommittee VI on General Castings (J. W. Bolton, chairman), and *Subcommittee XIV on Correlation of Test Bar and Casting* (R. S. MacPherran, chairman).—These subcommittees had planned a program of work in connection with checking up on the Tentative Specifications for Gray-Iron Castings (A 48 – 32 T). Owing to conditions in the industry during the past year, it will be necessary to continue this work during the coming year.

This report has been submitted to letter ballot of the committee, which consists of 95 members; 69 members returned their ballots, of whom 63 have voted affirmatively and none negatively.

Respectfully submitted on behalf of the committee,

HYMAN BORNSTEIN,
Chairman.

W. H. ROTHER,
Secretary.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 625 (1932); also 1932 Book of A.S.T.M. Tentative Standards, p. 179.

[2] 1930 Book of A.S.T.M. Standards, Part I, p. 494.

[3] 1931 Supplement to Book of A.S.T.M. Standards, p. 19.

EDITORIAL NOTE

The recommendation for the adoption as standard of the Tentative Specifications for Gray-Iron Castings which appeared in the report as preprinted was withdrawn at the annual meeting, see Summary of Proceedings, page 3, and the specifications are accordingly continued as tentative. The withdrawal of the Standard Specifications for Gray-Iron Castings and for High-Test Gray-Iron Castings, which the tentative specifications are intended to supersede, was approved.

REPORT OF SUBCOMMITTEE XV ON IMPACT TESTING

This subcommittee was charged with the duty of determining the usefulness of the several forms of impact test as applied to cast iron. It appeared necessary to subject a number of grades of commercial cast iron to the forms of impact test in general use and to obtain, at the same time, sufficient information on their general characteristics to enable the committee to draw intelligent conclusions as to the relation between the commonly accepted criteria and the results of the impact tests.

The cooperation of a number of prominent workers in the field of cast iron was secured and the necessary funds were obtained by subscriptions from the members of Committee A-3.

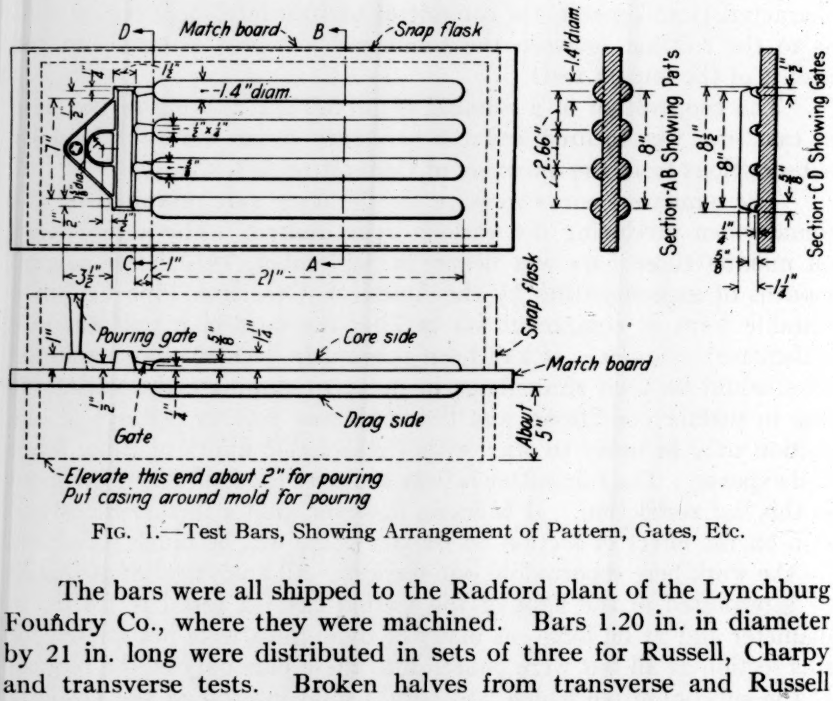
The numerous bars necessary for the tests were promised by the foundrymen producing the various irons desired. The actual work on making these bars was begun in September, 1930, after several months of experimenting by the American Cast Iron Pipe Co. on a suitable form of equipment for making the bars in a uniform and satisfactory manner. It had been previously decided that machined bars would be used throughout in order to eliminate the variations due to surface conditions, and the work was held to castings of one section only in order to stay within reasonable limits of time, labor and expense. The committee is fully aware of the limitations involved in this last restriction. It believes, however, that a further investigation on the effect of section on impact value will be much simplified by the work here reported on one section. All analytical data should be interpreted in the light of the section cast—a test bar 1.4 in. in diameter and 21 in. long—as many of these irons were not melted for this section at all but were poured into these bars only at the request of the subcommittee which had only a mild interest in the absolute values obtained, but a lively one in their relations to the impact tests.

MAKING AND MACHINING OF SPECIMENS

This report covers the data on 25 sets of cast-iron test bars with two exceptions, cast in green sand, as shown in Fig. 1. Each set was cast from a single ladle of iron and consisted of five flasks of four bars each. The two exceptions were irons J and V, which were cast in ordinary vertical dry-sand molds, J being cast open top and V with a pouring basin with a $\frac{1}{2}$-in. gate in the bottom of it. In all cases the diameter as cast was 1.4 in. and the length 21 in.

On sets A to S (except N) Roeser[1] and Spencer,[2] with a standardized optical pyrometer (Leeds and Northrup) and a rare-metal thermocouple (Wensel and Roeser[3]) went to each foundry for the casting operation, supervised the whole operation and read the melting and pouring temperatures of the iron, recorded its freezing point, and forwarded the patterns and flasks to the next foundry.

The data on iron N and on irons T to Z were obtained by Spencer and the Metallurgical Staff of the American Cast Iron Pipe Co.


D
Match board
B
Snap flask
1.4" diam.
7"
3 1/2"
C
1"
21"
A
1.4" diam.
2.66"
8"
Section-AB Showing Pat's
8 1/2"
8"
Section-CD Showing Gates
1 1/4"
Pouring gate
Core side
Snap flask
Match board
Drag side
About 5"
Gate

Elevate this end about 2" for pouring
Put casing around mold for pouring

FIG. 1.—Test Bars, Showing Arrangement of Pattern, Gates, Etc.

The bars were all shipped to the Radford plant of the Lynchburg Foundry Co., where they were machined. Bars 1.20 in. in diameter by 21 in. long were distributed in sets of three for Russell, Charpy and transverse tests. Broken halves from transverse and Russell tests were used for Russell 8-in. span and the drop tests. Tension and endurance specimens were cut from virgin bars. The other specimens were machined from the halves of the Charpy test, the quarters of the drop test and some from extra virgin bars. One extra 1.20 by 21-in. bar was sent to the American Cast Iron Pipe Co., and an extra tension specimen to Bolton for "set" determinations.

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[1] Physicist, U. S. Bureau of Standards, Washington, D. C.

[2] Metallurgist, American Cast Iron Pipe Co., Birmingham, Ala.

[3] *Transactions*, Am. Foundrymen's Assn., p. 191 (1928).

Chemical analysis, microscopic examinations and Rockwell and Brinell hardness determinations were made on the broken half of the transverse bar from the No. 3 flask, or the nearest possible to the average pouring temperature for the set.

TEST DATA

Chemical Analysis:

Chemical analyses were made by standard A.S.T.M. procedure,[1] except for the determinations of molybdenum, arsenic and tin, in which the new methods developed by the U. S. Bureau of Standards were employed. Messrs. R. H. Elder and Roy Deas made these determinations.

Transverse Tests:

The two American Cast Iron Pipe Co. transverse tests were made on a Riehle 5000-lb. universal machine with a Marshall recorder operated by the reader of a lever type deflectometer, reading to 0.001 in., following the bottom of the specimen. A punch mark was made at each 0.02 in. in the case of the large bars and at each 0.005 in. in the case of the small bars. As a check, an Ames dial reading to 0.001 in. was used to follow the motion of the cross-head and this was read at each 200 lb. on the large bars and each 50 lb. on the small bars. We, therefore, had two sets of curves—one (autographic) recording the load at each increment of deflection and the other giving the deflection at each increment of load. The agreement was in all cases within 5 per cent of the deflection and in most cases of the order of 2 per cent. The Frémont tests were made on the Guillery machine of the French Foundrymen's Association[2] which gives the load to 5 kg. and the deflection in 0.01 mm. The graphs are on a very small scale and quite difficult to read.

Tension, Compression, Endurance, Shear and Hardness Tests:

Tensile stress-strain tests were made by J. W. Bolton at the Lunkenheimer Co. plant. He used an Olsen 100,000-lb. universal machine with a traveler reducing it to 20,000 lb. for full beam. The specimen was well filleted (0.505 in. in diameter) and the ends were threaded for the grips. Robertson shackles held the specimens. Strain was read on 2-in. gage length by means of an Olsen strain gage reading directly to 0.0001 in. To tie in the Bolton specimen with the then standard tension test for cast iron (A 124-29)[1] Mr. Kuniansky made standard 0.8-in. diameter tests at the Lynchburg Foundry Co. plant on a Riehle 100,000-lb. machine, using threaded grips and spherical blocks in both heads of the machine.

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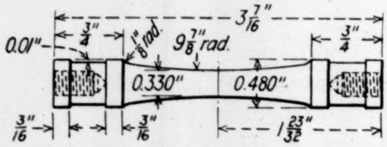
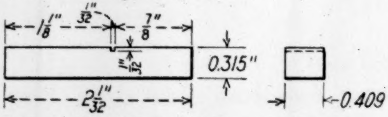
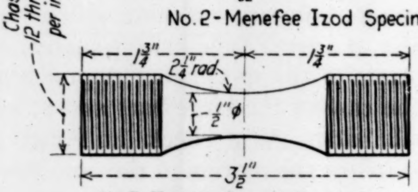
[1] Standard Methods of Sampling and Chemical Analysis of Pig and Cast Iron (A.S.T.M. Designation: A 64 – 27), 1930 Book of A.S.T.M. Standards, Part I, p. 506.

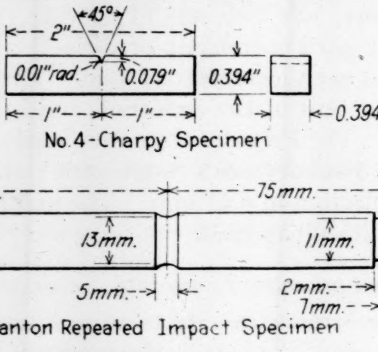
[2] *Transactions*, Am. Foundrymen's Assn., p. 695 (1931).

Compression tests were made by H. F. Moore at the University of Illinois. Spherical bearings were used in all tests, and the specimens were cylinders 1.20 in. in diameter by 4.0 in. long. One specimen was tested to failure without strain readings in a 200,000-lb. Riehle machine, running 0.05 in. per min. The other two were tested to approximately 50 per cent of the ultimate strength in a 100,000-lb. Amsler machine, recording the stress-strain diagram by the semi-


3 7/16"
3/4"
1/8" rad.
9 7/8" rad.
3/4"
0.01"
0.330"
0.480"
3/16"
3/16"
1 23/32"
No. 1-Kommers Fatigue Specimen


1 1/8"
1/32"
7/8"
1/32"
0.315"
2 1/32"
0.409"
No. 2-Menefee Izod Specimen


Chase 7/8"-12 threads per inch
1 3/4"
2 1/4" rad.
1 3/4"
1/2" φ
3 1/2"
No. 3-Tension-Impact Specimen


45°
2"
0.01" rad.
0.079"
0.394"
1"
1"
0.394"
No. 4-Charpy Specimen

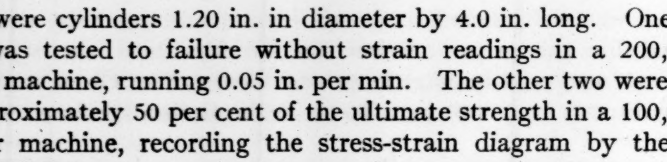

6 mm.
85 mm.
75 mm.
15 mm. φ
13 mm.
11 mm.
9 mm.
5 mm.
2 mm.
7 mm.
No. 5-Krupp-Stanton Repeated Impact Specimen

FIG. 2.—Test Specimens.

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[1] **Standard Specifications for the Arbitration Test Bar and Tension Test Specimen for Cast Iron (A.S.T.M. Designation: A 124-29), 1930 Book of A.S.T.M. Standards, Part I, p. 503.**

autographic method.[1] A strainometer reading to 0.000234 in. was used to measure compression.

After these tests, the two pieces were cut to 2.4 in. in length and tested to failure in a 300,000-lb. Olsen machine, running 0.05 in. per min. Moore remarks: "The 4-in. specimens failed at slightly lower average strength than did the shorter specimens, but this was by no means true for all series of specimens. The effect of this difference of length of specimens does not seem to be very marked."

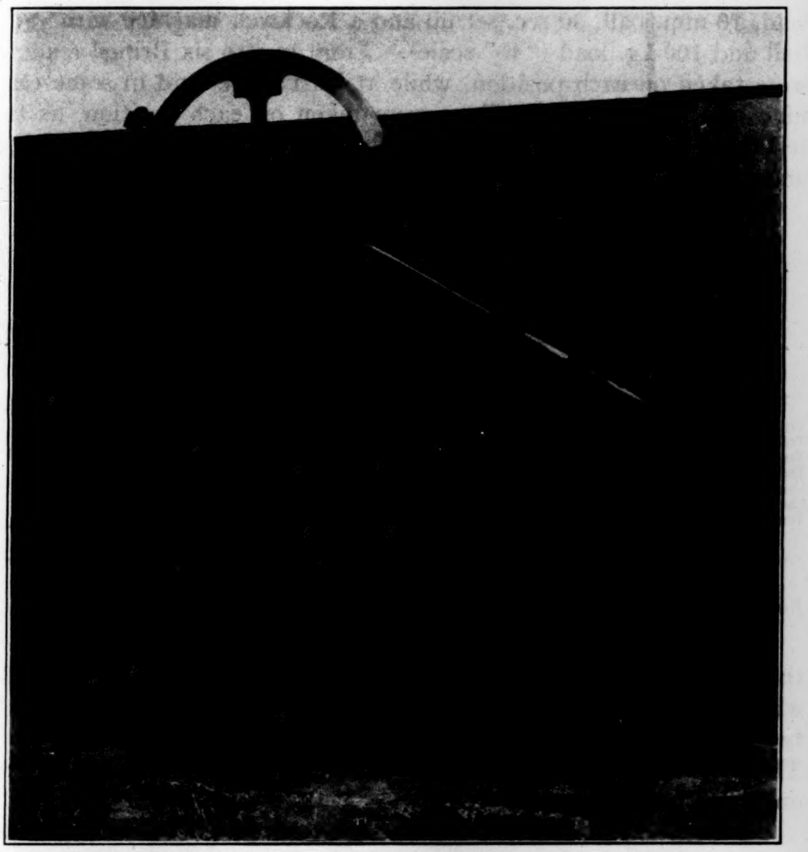

FIG. 3.—Charpy Machine Used for Transverse Impact Test.

Fatigue tests were made by J. B. Kommers at the University of Wisconsin. The R. R. Moore machine was used, taking special precautions against vibration. The specimens shown in Fig. 2 (No. 1) were rough turned, ground, polished with French emery papers Nos. 1 and 00 and finally polished with jewelers' rouge. The speed of the testing machine was 1750 r.p.m., making about 2,500,000 cycles a day.

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[1] H. F. Moore, "Rapid Semi-Autographic Tests for Determining the Proportional Limit," *Proceedings*, Am. Soc. Testing Mats., Vol. XVII, Part II, p. 589 (1917).

Shear tests were made on cylinders 0.505 in. in diameter by Bolton, using the double shear apparatus described by Elliott.[1]

Brinell and Rockwell hardness tests were made at the American Cast Iron Pipe Co., using an Olsen Brinell machine with the 3000-kg. load, 10-mm. ball, 30 sec. set up and a Rockwell machine with $\frac{1}{16}$-in. ball and 100-kg. load ("B" scale). From two to six Brinell readings were taken on each position, while at least three, and in some cases nine or ten Rockwell readings were taken on each position, as this test gives considerable scatter on the open-grain irons. Maximum and minimum values, however, are individual readings.

TABLE I.—DATA ON IMPACT MACHINES.

Nature of Test	Type of Machine	Capacity, ft-lb.	Weight of Hammer, lb.	Distance, Axis of Rotation to Striking Edge, in.	Location of Center of Percussion with Reference to Striking Edge, in.	Distance, Axis of Rotation to Center of Gravity, in.	Test Conducted by
Transverse.....	Charpy.....	120	82.44	49.00	1.68 above	35.07	Petrenko
Transverse.....	Russell.....	......	185	33.5	0.00	23.5	Kommers
Transverse.....	Charpy.....	21.3 or 15.1	5.07	......	......	24.2	Boegehold
Transverse.....	Charpy.....	240	44		Amsler Machine		Coyle
Cantilever.....	Izod........	10	8.08	20.63	1.88 above	8.56	Enger
Cantilever.....	Izod........	20	......	21.38	0.68 above	18.45	Menefee
Tension impact.	Charpy.....	224	53.11	29.46	0.88 below	27.31	Johnson

Impact Tests:

Charpy.—The Bureau of Standards tested the full-length bars in the Charpy machine shown in Fig. 3. The capacity was 120 ft-lb., which had to be increased for irons N, X and Z by adding weights to the striking head. The data on the machine are given in Table I. The specimen was a cylinder 1.20 in. in diameter by 21 in. long, tested on supports 18 in. apart.

Russell.—The Russell machine used by Kommers is illustrated in Fig. 4. The specimens were 1.20 in. in diameter. Tests were made first on 18-in. supports and then one-half of each bar was broken on 8-in. supports. The data on the machine are given in Table I.

Drop Tests:

This test is made by dropping a hammer from a small initial height on the bar resting on supports 5 or 6 in. apart on a heavy base.

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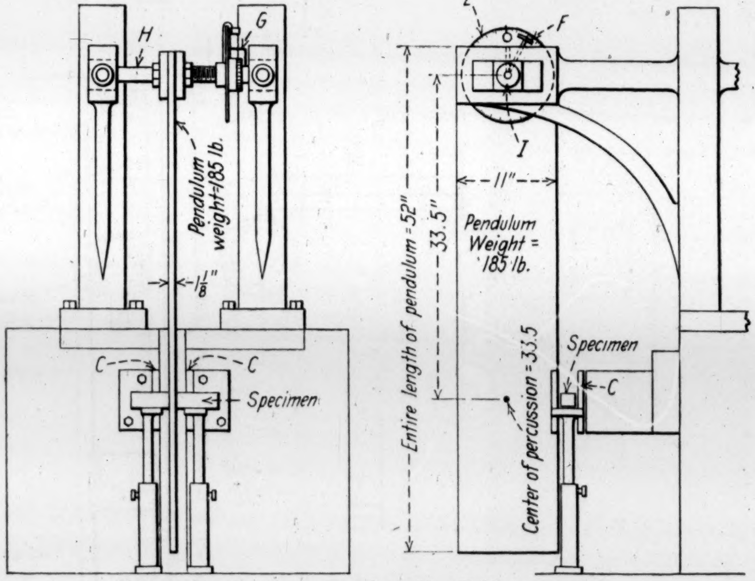
[1] *Transactions*, Am. Foundrymen's Assn., p. 865 (1926).


H
G
Pendulum weight=185 lb.
$1\frac{1}{8}''$
C
C
Specimen
E
F
I
11"
Entire length of pendulum = 52"
33.5"
Pendulum Weight = 185 lb.
Center of percussion = 33.5
Specimen
C

Distance from axis to center of gravity = 23.5"

FIG. 4.—Russell Pendulum Impact Machine.

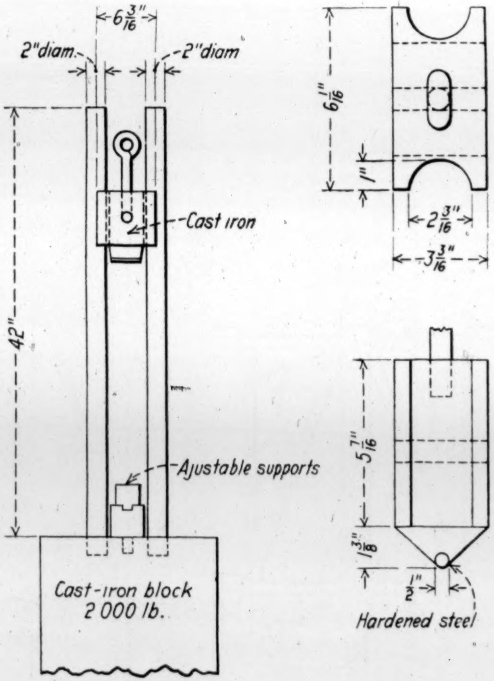

$6\frac{3}{16}''$
2"diam.
2"diam
Cast iron
42"
Ajustable supports
Cast-iron block 2 000 lb.
$6\frac{1}{16}''$
1"
$2\frac{3}{16}''$
$3\frac{3}{16}''$
$5\frac{7}{16}''$
$1\frac{3}{8}''$
$\frac{1}{2}''$
Hardened steel

FIG. 5.—25-lb. Hammer Drop Test Machine.

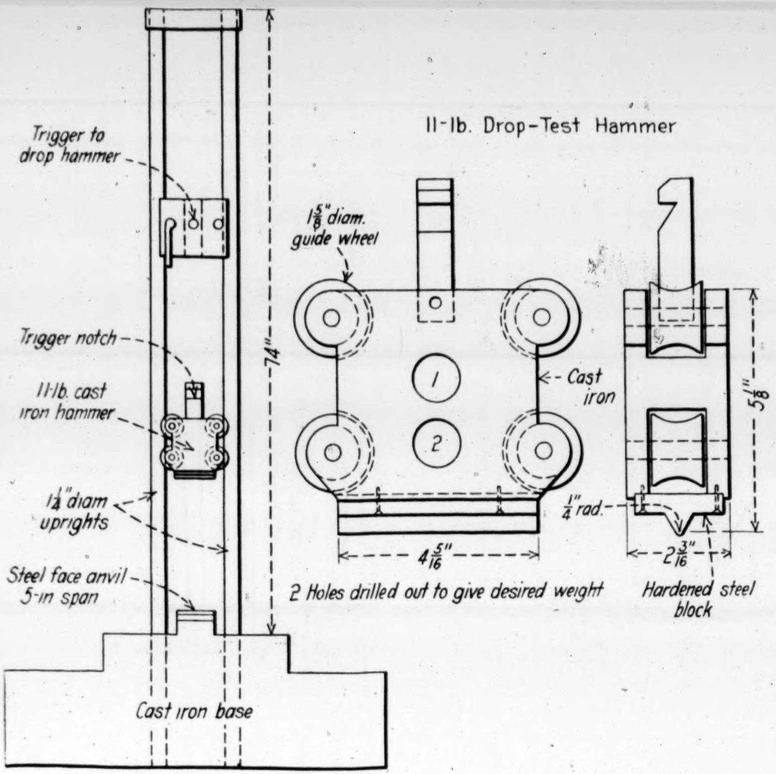

Trigger to drop hammer
Trigger notch
11-lb. cast iron hammer
1¼" diam uprights
Steel face anvil 5-in span
Cast iron base
74"
11-lb. Drop-Test Hammer
1 5/8" diam. guide wheel
1
2
Cast iron
4 5/16"
2 Holes drilled out to give desired weight
5 1/8"
¼" rad.
2 3/16"
Hardened steel block

FIG. 6.—11-lb. Hammer Drop Test Machine.

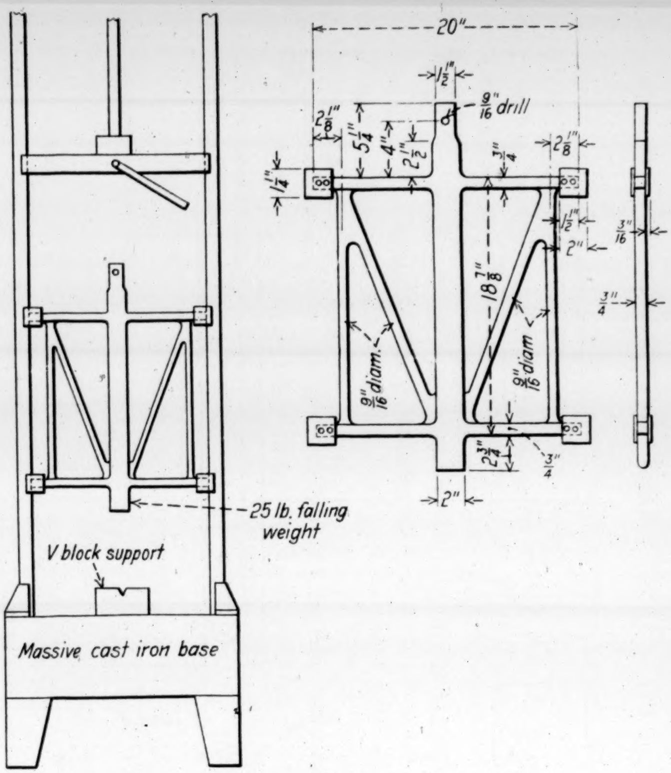

25 lb. falling weight
V block support
Massive cast iron base
20"
1½"
9/16" drill
2 1/8"
5¼"
4"
2½"
¾"
1¼"
½"
2"
3/16"
18 7/8"
9/16" diam.
9/16" diam
2¾"
2"

FIG. 7.—25-lb. Hammer Drop Test Machine.

The next blow is from a somewhat greater height, the increase in height being referred to as the increment, and the height of drop is increased, each blow, by this increment until the bar breaks. The height of the last drop is the figure reported. The diameter in all cases was 1.20 in. Care is taken to see that the bar is struck always at the same place circumferentially and longitudinally. The data on the several tests made for the committee are as follows:

Test No. 1.—25-lb. hammer; 6-in. span; 2-in. first drop; 0.5-in. increment. Detail of the hammer and machine are shown in Fig. 5.

FIG. 8.—Set-up for Unnotched Izod Test.

Test No. 2.—11-lb. hammer; 5-in. span; 1-in. first drop; 1.0-in. increment. Detail of hammer and machine are shown in Fig. 6.

Test No. 3.—25-lb. hammer; 6-in. span; 1-in. first drop; 1.0-in. increment. Detail of hammer and machine shown in Fig. 7.

Test No. 4.—25-lb. hammer; 6-in. span; 2-in. first drop; 2.0-in. increment. Detail of hammer and machine shown in Fig. 8.

It will be seen that the difference in the values for tests Nos. 1 and 4 and those for test No. 3 is apparently due to the greater friction of the apparatus used in test No. 3, which is readily explained by the shape of the hammer. Tests Nos. 1 and 4 show that a small change in increment is not important.

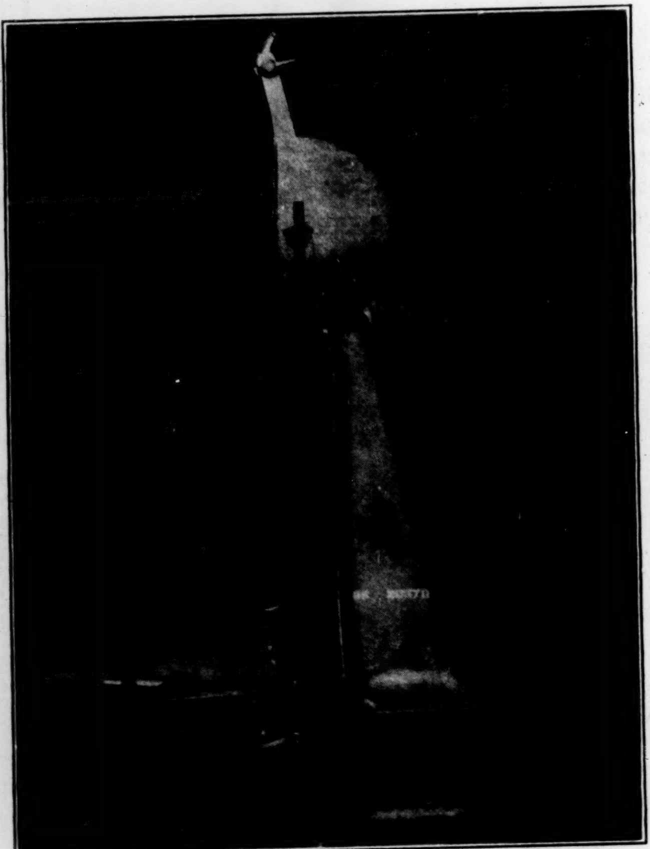


FIG. 9.—Charpy Machine Used for Tension Impact Test.

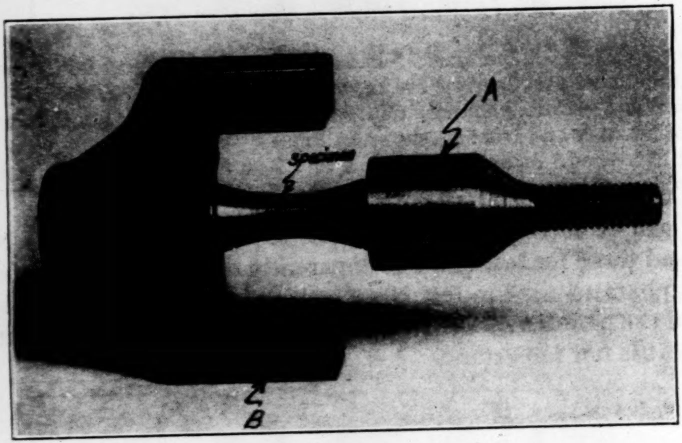


FIG. 10.—Tension Impact Specimen.

TABLE II.—CASTING DATA AND CHEMICAL ANALYSIS.

Iron	Casting Data						Average Chemical Analysis, per cent[a]																
	Furnace	Tapping Temperature, deg. Cent.	Pouring Temperature, deg. Cent.	Freezing Point, deg. Cent.	Mix; 100 per cent minus Cast-Iron Scrap		Total Carbon	Graphite	Combined Carbon, by difference	Combined Carbon, by color	Silicon	Phosphorus	Manganese	Sulfur, gravimetric	Sulfur, evolved as H_2S	Nickel	Chromium	Molybdenum	Titanium	Vanadium	Arsenic	Copper	Tin
					Steel, per cent	Pig Iron, per cent																	
A	Cupola	1425	1285	1140	10	70	3.49	2.72	0.77	0.67	1.68	0.74	0.54	0.074	0.064	0.00	0.01	0.00	0.07	0.02	0.06	0.10	0.01
B	Cupola	1472	1420	1137	12	67	3.53	2.69	0.84	0.76	1.67	0.68	0.56	0.076	0.074	0.00	0.00	0.00	0.06	0.01	0.07	0.06	0.01
C	Cupola	1483	1352	1158	10	90	3.95	3.09	0.86	0.78	1.90	0.07	0.65	0.060	0.062	0.01	0.00	0.00	0.04	0.00	0.03	0.32	0.01
D	Cupola	1499	1331	1105	13	67	3.25	2.66	0.59	0.61	2.08	1.99	0.53	0.050	0.050	0.03	0.00	0.00	0.16	0.03	0.05	0.02	0.02
E	Cupola	1465	1322	1174	4	56	3.12	2.44	0.68	0.71	2.18	0.63	0.44	0.096	0.090	0.00	0.00	0.00	0.06	0.01	0.07	0.02	0.01
F	Cupola	1428	1279	1133	10	75	3.61	2.93	0.68	0.55	2.06	0.75	0.52	0.062	0.060	0.00	0.00	0.00	0.08	0.01	0.08	0.02	0.01
G	Cupola	1590	1312	1152	20	35	3.49	2.78	0.71	0.65	2.08	0.19	0.55	0.078	0.072	1.17	0.65	0.00	0.05	0.03	0.01	0.02	0.02
H	Cupola	1444	1302	1175	10	35	3.39	2.75	0.64	0.52	2.50	0.43	0.74	0.062	0.062	0.01	0.00	0.00	0.16	0.03	0.01	0.04	0.03
I	Cupola	1454	1264	1139	0	53	3.41	2.85	0.56	0.57	2.44	0.63	0.57	0.070	0.068	0.01	0.02	0.00	0.10	0.02	0.02	0.03	0.02
J	Cupola	1494	1322	1214	85	..	2.61	1.73	0.88	0.83	2.38	0.06	0.77	0.105	0.095	1.08	0.09	0.00	0.02	0.00	0.01	0.05	0.01
K	Arc Furnace	1658	1367	1173	20	0	3.14	2.30	0.84	0.83	2.69	0.18	0.82	0.094	0.081	0.25	0.09	0.07	0.04	0.00	0.02	0.06	0.12
L	Arc Furnace	1649	1364	1181	20	0	3.05	2.20	0.85	0.76	2.70	0.16	0.79	0.089	0.060	0.60	0.24	0.45	0.03	0.00	0.01	0.02	0.04
M	Cupola	1499	1347	1164	25	28	3.46	2.82	0.64	0.58	2.35	0.15	0.69	0.092	0.084	0.65	0.02	0.02	0.04	0.00	0.01	0.03	0.01
N	Arc Furnace	1590	1335	1223	0	100	2.53	2.03	0.50	0.47	3.26	0.02	1.01	0.035	0.035	10.59	1.55	0.00	0.05	0.01	0.02	4.07	0.03
O	Cupola	1572	1360	1172	13	41	3.43	2.75	0.68	0.59	2.35	0.20	0.73	0.092	0.081	0.01	0.01	0.00	0.04	0.00	0.01	0.03	0.01
Q	Rocking Electric Furnace	1590	1351	1172	23	0	2.88	2.25	0.63	0.68	1.99	0.43	0.51	0.098	0.092	0.01	0.01	0.00	0.05	0.01	0.01	0.04	0.01
R	Air Furnace	1475	1356	1177	0	50	3.24	2.41	0.83	0.77	1.63	0.42	0.56	0.084	0.079	0.06	0.01	0.00	0.09	0.01	0.02	0.04	0.01
S	Cupola	1475	1272	1172	40	60	3.38	2.59	0.79	0.67	1.18	0.14	0.82	0.077	0.073	0.95	0.01	0.00	0.05	0.01	0.01	0.05	0.01
T	Cupola	1450	1306	1180	0	2	3.49	2.16	1.33	1.48	0.53	0.33	0.42	0.133	0.111	0.00	0.01	0.00	0.01	0.01	0.01	0.05	0.00
U	Arc Furnace	1652	1360	1164	12	88	3.52	2.68	0.84	0.69	2.94	0.04	0.66	0.042	0.048	0.01	0.01	0.00	0.03	0.00	0.03	0.34	0.00
V	Cupola	1457	1334	1218	85	15	2.50	1.50	1.00	0.79	2.20	0.04	0.74	0.088	0.082	0.00	0.08	0.00	0.01	0.01	0.01	0.12	0.01
W	Cupola	1518	1358	1163	37	63	3.79	2.99	0.80	0.76	1.47	0.12	0.73	0.083	0.078	0.01	0.01	0.00	0.11	0.01	0.04	0.21	0.00
X	Arc Furnace	1554	1412	1145	0	100	3.08	2.32	0.76	0.40	2.07	0.04	1.21	0.047	0.040	16.29	1.89	0.00	0.04	0.04	0.01	6.12	0.01
Y	Rotary Coal Fired	1533	1296	1142	12	50	3.07	2.22	0.85	0.77	1.97	0.40	0.63	0.072	0.070	0.01	0.00	0.00	0.04	0.01	0.02	0.12	0.00
Z	Arc Furnace	1526	1448	1170	68	32	2.79	1.94	0.85	0.77	2.44	0.03	0.50	0.060	0.056	0.50	0.09	0.00	0.02	0.01	0.06	0.36	0.01

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[a] All specimens were examined for tungsten and were found to contain less than 0.01 per cent.

PRINT IN

TABLE III.—RESULTS OF TRANSVERSE, TENSION, FATIGUE, COMPRESSION AND SHEAR TESTS.

Iron		Transverse Tests													Tension			Endurance Limit, 0.330-in. Diameter Bar	Compression, 1.20-in. Diameter Bar		Shear, 0.505-in. Diameter Bar, lb. per sq. in. × 10⁻³	Iron	
		Standard 1.20-in. Diameter Bar, 18-in. Span						0.5-in. Diameter Bar, 5-in. Span				8 by 10-mm. Bar, 30-mm. Span			0.505-in. Diameter Bar								
		Load, lb.	Deflection, in.	Resilience, in-lb.	Modulus of Rupture, lb. per sq. in. × 10⁻³	Modulus of Elasticity (Ult.), lb. per sq. in. × 10⁻⁶	Modulus of Elasticity (¼ Load), lb. per sq. in. × 10⁻⁶	Modulus of Rupture, lb. per sq. in. × 10⁻³	Modulus of Elasticity (Ult.), lb. per sq. in. × 10⁻⁶	Modulus of Elasticity (¼ Load), lb. per sq. in. × 10⁻⁶	Resilience, in-lb.	Modulus of Rupture, lb. per sq. in. × 10⁻³	Modulus of Elasticity (Ult.), lb. per sq. in. × 10⁻⁶	Resilience, in-lb.	Tensile Strength, lb. per sq. in. × 10⁻³	Modulus of Elasticity (¼ Load), lb. per sq. in. × 10⁻⁶	Tensile Strength, 0.80-in. Diameter Bar, lb. per sq. in. × 10⁻³		Compressive Strength, lb. per sq. in. × 10⁻³	Modulus of Elasticity (¼ Load), lb. per sq. in. × 10⁻⁶			
A......	Min....	2390	0.275	401	......	9.8	14.3	63.4	8.2	12.1	24.0	55.0	4.20	......	29.05	11.3	31.07	......	108.9	10.0	39.3	....Min.	......A
	Max....	2534	0.289	442	......	10.5	15.1	65.6	8.6	13.4	27.2	56.0	7.00	......	29.95	11.5	32.56	......	113.1	10.4	41.0	....Max.	
	Avg....	2457	0.284	425	65.1	10.4	14.8	64.4	8.4	12.7	25.1	55.7	5.30	5.93	29.47	11.4	31.64	14.8	111.0	10.2	40.2	....Avg.	
B......	Min....	2170	0.263	338	......	9.6	13.0	58.1	7.4	11.6	23.7	48.0	6.00	......	26.85	10.3	28.93	......	106.8	9.4	36.7	....Min.	......B
	Max....	2362	0.295	429	......	9.9	14.3	62.9	8.7	12.7	26.9	51.0	7.36	......	29.00	10.7	29.06	......	107.4	10.0	39.3	....Max.	
	Avg....	2342	0.293	416	62.2	9.6	13.7	61.2	8.0	12.1	25.2	49.3	6.46	4.01	28.50	10.5	29.00	14.1	107.2	9.7	38.0	....Avg.	
C......	Min....	1394	0.334	301	......	4.8	8.4	43.6	4.7	8.1	18.6	33.5	3.75	......	17.35	6.3	17.81	......	63.4	6.4	......	....Min.	C
	Max....	1440	0.354	331	......	5.0	8.4	45.1	5.2	8.9	22.4	44.0	6.38	......	19.20	6.3	18.30	......	67.5	6.5	......	....Max.	
	Avg....	1420	0.352	325	37.7	4.8	8.4	44.5	5.0	8.5	20.6	37.2	4.70	3.00	18.32	6.3	18.13	8.8	65.2	6.5	28.9	....Avg.	
D......	Min....	1203	0.135	94	......	10.3	11.9	44.9	8.5	9.6	10.4	36.0	7.51	......	20.65	10.5	19.74	......	88.9	10.0	......	....Min.	......D
	Max....	1316	0.149	112	......	11.0	13.0	46.8	8.8	11.2	12.1	39.0	9.15	......	22.00	10.5	20.70	......	92.8	16.1	......	....Max.	
	Avg....	1254	0.141	100	33.3	10.6	12.6	45.8	8.7	10.5	11.1	37.3	8.07	1.58	21.28	10.5	20.22	12.3	90.9	12.3	27.5	....Avg.	
E......	Min....	2726	0.290	477	......	10.7	15.9	67.5	8.6	12.4	25.0	57.0	7.63	......	31.90	12.8	31.86	......	119.0	10.0	......	....Min.	......E
	Max....	2819	0.315	544	......	11.3	16.7	73.4	9.3	14.8	31.4	62.0	8.30	......	33.10	14.6	34.68	......	122.5	10.0	......	....Max.	
	Avg....	2758	0.301	504	73.2	10.9	16.2	71.2	9.1	13.6	28.3	60.2	8.06	4.64	32.50	13.6	33.15	16.5	120.8	10.0	44.6	....Avg.	
F......	Min....	1824	0.245	264	......	8.6	11.9	51.7	6.5	10.1	20.8	43.0	4.49	......	22.25	8.6	21.30	......	87.8	9.2	......	....Min.	......F
	Max....	1881	0.261	298	......	9.0	12.7	55.3	7.0	11.2	22.3	46.0	6.16	......	22.75	8.9	23.09	......	92.6	10.0	......	....Max.	
	Avg....	1857	0.251	279	49.2	8.8	12.4	53.1	6.8	10.5	21.3	44.8	5.36	3.81	22.42	8.7	22.28	11.4	91.0	9.6	33.0	....Avg.	
G......	Min....	2380	0.282	384	......	9.4	13.4	65.9	8.0	12.2	26.2	53.5	5.33	......	30.30	10.7	31.08	......	106.9	11.2	......	....Min.	......G
	Max....	2662	0.335	536	......	10.1	13.4	69.4	8.4	12.2	28.8	61.0	6.72	......	31.80	10.7	32.36	......	111.0	11.7	......	....Max.	
	Avg....	2651	0.331	531	70.3	9.6	13.4	67.7	8.3	12.2	27.8	56.2	5.86	5.38	29.98	10.7	31.72	13.5	108.8	11.5	42.3	....Avg.	
H......	Min....	2315	0.236	322	......	11.4	15.1	66.2	11.0	15.6	17.4	54.0	7.23	......	31.50	12.8	31.95	......	115.1	10.0	......	....Min.	......H
	Max....	2495	0.260	385	......	12.0	15.9	66.9	11.9	15.6	19.9	58.0	8.44	......	31.50	12.8	32.59	......	117.5	10.5	......	....Max.	
	Avg....	2407	0.245	352	63.9	11.7	15.6	66.6	11.4	15.6	18.8	55.3	7.80	3.75	31.50	12.8	32.34	18.6	116.1	10.3	42.2	....Avg.	
I......	Min....	1825	0.265	295	......	7.9	11.9	39.6	5.1	7.4	14.8	35.0	3.65	......	14.10	8.0	19.32	......	86.2	8.3	......	....Min.	I
	Max....	1861	0.281	322	......	8.3	11.9	43.4	5.2	9.4	19.3	37.0	5.05	......	20.05	8.0	20.35	......	88.0	8.6	......	....Max.	
	Avg....	1840	0.274	308	48.8	8.0	11.9	41.8	5.1	8.4	17.7	35.7	4.27	3.09	20.00	8.0	19.98	9.4	87.2	8.5	27.7	....Avg.	
J......	Min....	3235	0.246	445	......	14.5	18.2	99.8	14.0	16.3	32.2	84.0	7.58	......	44.00	15.5	49.56	......	147.5	12.3	......	....Min.	......J
	Max....	3920	0.323	736	......	16.1	19.4	108.5	14.7	17.7	37.1	91.0	10.66	......	59.05	17.2	51.98	......	162.5	14.0	......	....Max.	
	Avg....	3480	0.272	547	92.5	15.3	18.6	103.4	14.4	17.0	34.5	88.0	9.02	7.70	51.44	16.2	50.96	24.0	156.6	13.1	61.0	....Avg.	

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K	Min	[illegible]	[illegible]	[illegible]	......	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	......	[illegible]	[illegible]	[illegible]	......	[illegible]	[illegible]	......	Min.	K
	Max	2631	0.296	469	......	11.0	14.8	73.0	9.8	13.5	27.2	67.0	6.28	......	35.80	12.8	35.44	......	116.8	10.0	......	Max.	
	Avg	2590	0.293	461	69.7	10.5	14.8	71.7	9.8	12.9	25.3	61.3	5.31	6.81	35.65	12.6	34.43	16.5	115.9	9.9	44.3	Avg.	
L	Min	3000	0.285	498	......	11.7	15.6	79.2	11.6	14.8	23.3	67.0	6.14	......	37.75	14.3	40.71	......	124.7	10.9	......	Min.	L
	Max	3170	0.323	611	......	12.6	17.9	91.9	12.7	16.2	35.3	72.0	7.85	......	40.60	14.3	43.60	......	135.0	11.3	......	Max.	
	Avg	3083	0.301	546	81.8	12.4	16.6	86.0	12.1	15.5	29.2	69.0	6.81	6.64	39.20	14.3	41.76	18.2	131.2	11.1	44.2	Avg.	
M	Min	2165	0.329	451	......	7.8	12.5	55.8	5.6	9.1	26.6	45.0	3.08	......	23.85	10.0	24.25	......	87.9	7.8	......	Min.	M
	Max	2259	0.346	498	......	7.9	13.1	56.9	6.5	10.3	31.0	46.0	3.92	......	24.75	10.0	25.48	......	94.2	8.3	......	Max.	
	Avg	2200	0.335	468	58.3	7.8	12.7	56.5	6.0	9.9	28.8	45.7	3.43	6.54	24.45	10.0	24.84	12.0	90.8	8.0	34.2	Avg.	
N	Min	2356	0.425	655	......	5.2	10.0	71.5	4.7	8.5	51.0	50.0	2.04	......	28.10	7.1	29.05	......	109.7	5.7	......	Min.	N
	Max	2460	0.547	862	......	6.8	11.0	73.7	5.4	9.9	62.0	58.0	2.62	......	31.60	7.9	33.33	......	151.0	6.3	......	Max.	
	Avg	2414	0.471	734	64.4	6.2	10.5	72.8	5.0	9.3	56.6	53.3	2.21	13.83	29.73	7.4	31.75	12.8	134.2	6.0	43.8	Avg.	
O	Min	2185	0.338	466	......	7.3	12.5	56.9	6.6	10.3	23.8	42.0	3.39	......	24.80	9.4	24.98	......	94.0	7.7	......	Min.	O
	Max	2257	0.360	521	......	7.8	13.1	59.7	7.2	10.8	28.0	47.0	4.92	......	25.35	10.0	27.26	......	96.5	8.0	......	Max.	
	Avg	2218	0.341	494	58.7	7.7	12.7	58.1	6.9	10.6	25.6	44.3	4.04	5.06	25.02	9.7	25.86	11.8	95.0	7.8	35.5	Avg.	
Q	Min	3080	0.426	937	......	8.2	16.0	83.4	8.3	15.5	43.4	73.0	6.09	......	40.10	14.3	40.72	......	116.3	9.6	......	Min.	Q
	Max	3301	0.450	959	......	9.3	16.6	90.5	8.7	16.2	55.3	78.0	6.31	......	42.30	15.4	42.79	......	120.5	10.0	......	Max.	
	Avg	3177	0.439	947	84.2	8.6	16.2	86.8	8.6	15.7	48.5	75.0	6.21	9.89	40.92	14.8	41.71	19.6	119.1	9.8	47.3	Avg.	
R	Min	2880	0.318	570	......	10.5	16.7	68.6	8.8	13.5	25.7	60.0	6.00	......	33.75	13.3	35.81	......	118.4	10.0	......	Min.	R
	Max	2939	0.330	600	......	10.8	16.7	72.6	10.0	15.6	30.7	64.0	6.36	......	36.80	13.3	39.10	......	122.5	10.6	......	Max.	
	Avg	2905	0.326	584	77.0	10.6	16.7	70.8	9.4	14.2	27.5	61.7	6.20	6.30	35.08	13.3	37.52	17.4	120.8	10.3	47.6	Avg.	
S	Min	2382	0.250	363	......	10.6	15.1	63.6	8.4	12.9	23.4	55.0	4.91	......	30.50	12.0	30.26	......	110.6	9.8	......	Min.	S
	Max	2575	0.290	453	......	11.4	16.9	66.8	8.9	14.3	27.3	57.0	5.16	......	30.95	12.5	33.27	......	114.5	10.0	......	Max.	
	Avg	2455	0.267	397	65.0	11.0	15.9	65.5	8.7	13.6	25.2	55.7	5.08	6.25	30.65	12.2	32.08	16.0	112.0	9.9	41.0	Avg.	
T	Min	2720	0.210	341	......	10.0	18.5	......	......	......	......	......	......	......	32.65	14.8	34.02	......	121.3	9.6	......	Min.	T
	Max	2965	0.355	703	......	15.5	20.9	......	......	......	......	......	......	......	36.75	15.2	36.66	......	126.0	10.4	......	Max.	
	Avg	2835	0.294	543	75.2	12.0	19.4	......	......	......	......	......	......	......	34.95	15.0	35.73	......	123.5	10.0	47.8	Avg.	
U	Min	1565	0.328	319	......	5.1	8.0	44.7	5.3	8.1	18.9	37.0	2.89	......	18.85	6.0	17.53	......	71.2	6.9	......	Min.	U
	Max	1652	0.390	415	......	5.7	8.7	47.1	5.4	8.5	21.2	39.0	3.85	......	19.75	6.0	17.94	......	75.3	7.0	......	Max.	
	Avg	1651	0.370	390	43.8	5.3	8.3	45.9	5.3	8.4	20.2	37.7	3.37	4.29	19.43	6.0	17.70	10.0	72.8	7.0	29.6	Avg.	
V	Min	3393	0.216	408	......	16.7	21.4	94.5	15.8	18.6	25.4	73.0	7.60	......	46.50	20.0	46.60	......	152.5	13.6	......	Min.	V
	Max	3577	0.247	487	......	18.9	22.5	95.1	16.1	18.6	26.7	82.0	9.50	......	48.40	20.0	49.88	......	162.3	14.6	......	Max.	
	Avg	3472	0.230	447	92.0	18.0	22.1	94.8	16.0	18.6	26.0	77.0	8.34	6.46	47.23	20.0	48.06	25.2	159.0	14.1	60.8	Avg.	
W	Min	1695	0.324	370	......	6.0	9.8	40.4	5.3	8.9	15.9	35.0	2.81	......	17.90	6.4	17.45	......	74.8	5.9	......	Min.	W
	Max	1835	0.346	391	......	6.8	10.8	43.9	5.7	9.4	16.8	39.0	4.30	......	18.50	6.8	18.87	......	82.2	7.6	......	Max.	
	Avg	1771	0.336	379	47.0	6.3	10.2	42.0	5.5	9.1	16.4	36.7	3.44	3.95	18.27	6.6	18.40	8.2	77.9	6.6	30.4	Avg.	
X	Min	1920	0.645	952	......	2.7	9.9	44.5	2.5	7.3	48.1	38.0	1.15	......	15.00	8.9	22.10	......	76.1	5.3	......	Min.	X
	Max	2033	0.900	1396	......	3.6	10.8	51.4	3.1	9.7	52.3	46.0	1.57	......	18.10	11.4	22.62	......	102.9	5.5	......	Max.	
	Avg	1970	0.745	1134	52.2	3.2	10.5	48.0	2.8	8.5	50.2	43.0	1.37	16.40	16.7	10.0	22.40	10.6	86.0	5.4	33.9	Avg.	
Y	Min	2740	0.293	477	......	10.2	14.7	72.1	8.7	13.3	27.0	54.5	5.11	......	28.4	12.7	34.53	......	121.2	9.0	......	Min.	Y
	Max	2815	0.330	569	......	11.2	16.7	75.5	9.8	16.1	33.3	60.0	6.81	......	32.1	12.7	37.69	......	127.8	9.5	......	Max.	
	Avg	2776	0.308	518	73.5	10.8	15.7	74.2	9.2	14.2	30.2	57.5	5.58	5.97	29.2	12.7	35.97	16.2	124.5	9.3	44.3	Avg.	
Z	Min	3955	0.435	1150	......	9.6	17.0	115.8	9.6	15.0	64.6	98.0	5.98	......	53.4	16.0	54.97	......	116.5	10.8	......	Min.	Z
	Max	4365	0.523	1523	......	10.8	19.0	118.1	11.2	18.9	73.9	102.0	7.06	......	59.1	17.0	55.77	......	147.0	11.3	......	Max.	
	Avg	4200	0.490	1370	111.7	10.2	18.0	116.8	10.2	16.6	70.0	99.3	6.42	15.98	56.7	16.4	55.46	25.0	135.7	11.1	57.1	Avg.	

TABLE IV.—RESULTS OF HARDNESS AND IMPACT TESTS.

Iron		Hardness						Impact													Iron	
		Brinell			Rockwell "B" Scale			Pendulum Tests, 1.20-in. Diameter Bar, ft-lb.			Drop Test, 1.20-in. Diameter Bar, Average Drop, in.				Izod, ft-lb.		Charpy, ft-lb.					
											No. 1	No. 2	No. 3	No. 4								
		Center	Halfway	Edge	Center	Halfway	Edge	Charpy, 18-in. Span	Russell, 18-in. Span	Russell, 8-in. Span	25-lb. Hammer, 6-in. Span, 2-in. First Drop, ½-in. Increment	11-lb. Hammer, 5-in. Span, 1-in. First Drop, 1-in. Increment	25-lb. Hammer, 6-in. Span, 1-in. First Drop, 1-in. Increment	25-lb. Hammer, 6-in. Span, 2-in. First Drop, 2-in. Increment	Small Specimen, Unnotched	Small Specimen, Notched	Small Specimen, Notched	Small Specimen, Unnotched	Krupp Stanton, Repeated Blow	Direct Tension, 0.5-in. Diameter Bar, ft-lb.		
A......	Min.....	183	179	207	84.5	86.0	85.0	33.5	510	336	10.5	14.0	17.0	10	3.56	0.8	0.50	2.5	2694	6.1	....Min.	.....A
	Max.....	183	187	207	90.0	91.0	92.5	53.0	578	372	10.5	20	18.0	12	3.91	0.9	1.00	3.1	4394	8.8	....Max.	
	Avg.....	183	183	207	87.0	89.0	90.0	47.3	551	351	10.5	20	17.3	11.5	3.68	0.9	0.83	2.9	3424	7.2	....Avg.	
B......	Min.....	179	179	187	87.0	84.0	86.5	43.5	472	249	9.0	19	16.0	12	3.57	0.7	0.75	2.3	1773	6.8	....Min.	.....B
	Max.....	179	187	192	91.0	90.5	91.0	56.6	543	353	9.5	21	17.0	12	4.20	0.9	1.0	2.8	6111	8.9	....Max.	
	Avg.....	179	183	190	88.5	88.5	89.0	54.7	496	345	9.2	20	16.7	12.0	3.96	0.8	0.83	2.6	3703	7.5	....Avg.	
C......	Min.....	131	131	131	53.0	69.0	51.0	40.1	396	285	7.0	15	11.0	8	4.01	0.8	1.0	3.0	906	5.4	....Min.	C
	Max.....	131	134	134	74.0	73.5	75.0	44.0	489	311	7.0	16	13.0	8	4.20	0.8	1.0	3.6	3854	7.3	....Max.	
	Avg.....	131	133	133	66.0	71.5	67.5	42.2	473	299	7.0	15.3	12.0	8.0	4.14	0.8	1.0	3.3	2241	6.2	....Avg.	
D......	Min.....	179	179	196	82.0	87.0	89.5	15.5	143	149	4.0	9	6.0	4	2.13	0.9	0.25	1.9	220	3.4	....Min.	.....D
	Max.....	179	179	196	87.0	90.5	92.5	21.0	158	205	4.5	12	8.0	6	2.21	1.0	0.50	2.2	2290	5.1	....Max.	
	Avg.....	179	179	196	84.5	89.0	90.5	17.6	151	151	4.3	11	6.7	4.7	2.17	1.0	0.42	2.1	1116	4.4	....Avg.	
E......	Min.....	187	192	207	85.0	89.0	85.0	57.0	606	384	11.0	21	20.0	14	3.56	1.2	0.75	2.1	1946	6.4	....Min.	.....E
	Max.....	187	192	207	92.0	92.5	95.0	61.7	673	457	11.5	23	21.0	14	4.63	1.5	1.00	2.8	6003	10.0	....Max.	
	Avg.....	187	192	207	90.0	90.5	91.5	60.9	641	416	11.2	22	20.3	14.0	4.15	1.4	0.83	2.5	3312	8.6	....Avg.	
F......	Min.....	163	163	179	69.0	80.5	80.0	30.5	417	249	7.5	15	10.0	8	3.32	1.0	0.75	2.5	402	5.3	....Min.	.....F
	Max.....	163	163	183	87.0	86.0	90.0	39.3	445	314	7.5	17	13.0	8	3.80	1.0	0.75	2.8	1703	6.8	....Max.	
	Avg.....	163	163	181	82.0	84.0	86.0	38.5	430	278	7.5	15.7	11.7	8.0	3.60	1.0	0.75	2.6	1029	6.1	....Avg.	
G......	Min.....	183	179	196	82.0	83.0	88.0	55.0	558	367	10.0	22	17.0	12	3.96	1.4	1.00	2.7	682	4.9	....Min.	.....G
	Max.....	183	183	202	89.5	90.5	92.0	57.4	642	408	11.5	25	19.0	14	4.50	1.5	7.00	3.1	7476	8.9	....Max.	
	Avg.....	183	181	199	87.0	86.0	90.0	56.6	587	383	10.8	23	17.7	13.5	4.16	1.5	3.00	2.9	4647	6.8	....Avg.	
H......	Min.....	192	196	196	90.5	90.0	88.0	37.9	445	275	9.0	17	13.0	10	3.25	1.2	0.50	2.5	2412	8.9	....Min.	.....H
	Max.....	192	196	196	93.5	91.5	94.5	44.6	479	342	9.5	20	16.0	12	3.32	1.3	0.75	2.7	4448	9.7	....Max.	
	Avg.....	192	196	196	91.5	90.5	91.5	41.1	461	339	9.2	19	14.0	11.0	3.28	1.3	0.67	2.6	3145	9.2	....Avg.	
I.......	Min.....	143	156	170	70.0	73.0	75.0	40.0	424	279	7.0	15	10.0	8	3.24	1.0	0.75	2.5	441	4.9	....Min.	I
	Max.....	149	159	174	79.0	81.0	84.0	40.5	430	298	7.0	17	13.0	8	3.50	1.0	0.75	2.8	560	6.8	....Max.	
	Avg.....	146	158	172	76.0	78.5	81.0	40.3	427	290	7.0	16	11.7	8.0	3.39	1.0	0.75	2.7	503	5.3	....Avg.	
J.......	Min.....	269	269	269	99.0	102.0	100.0	67.0	584	454	13.5	27	20.	16	5.68	1.5	1.00	2.9	4090	9.6	....Min.	.....J
	Max.....	269	269	277	103.0	103.0	103.0	86.0	998	567	17.0	35	30.	20	5.70	1.5	1.00	3.1	12835	13.2	....Max.	

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	Avg.	146	158	172	76.0	78.5	81.0	40.3	427	290	7.0	16	11.7	8.0	3.39	1.0	0.75	2.7	503	5.3	Avg.	
J	Min.	269	269	269	99.0	102.0	100.0	67.0	584	454	13.5	27	20.	16	5.68	1.5	1.00	2.9	4090	9.6	Min.	J
	Max.	269	269	277	103.0	103.0	103.0	86.0	998	567	17.0	35	30.	20	5.70	1.5	1.00	3.1	12835	13.2		
	Max.	196	196	196	94.0	95.0	95.0	59.0	644	429	10.5	25	17.0	14	4.11	1.2	1.00	2.8	2234	8.3	Max.	K
	Avg.	194	194	196	93.0	93.0	93.0	57.6	641	401	10.2	24.7	15.3	13.5	3.86	1.1	0.83	2.6	1849	7.5	Avg.	
L	Min.	228	228	228	95.0	94.5	95.0	62.8	623	435	13.0	29	21.0	16	4.57	1.5	0.75	2.9	2634	10.4	Min.	L
	Max.	228	228	228	99.0	98.0	98.5	67.5	836	549	14.0	33	23	16	5.66	1.7	1.00	3.2	3211	13.0	Max.	
	Avg.	228	228	228	98.0	96.0	96.5	67.4	806	487	13.5	31.3	22.3	16.0	5.06	1.6	0.83	3.1	2923	11.5	Avg.	
M	Min.	153	159	163	81.0	78.0	84.0	61.0	632	413	9.5	20	14.0	12	5.36	1.2	1.00	3.1	461	7.9	Min.	M
	Max.	156	163	166	85.5	88.0	87.5	63.0	688	433	10.5	23	19.0	12	5.61	1.3	1.00	3.6	667	9.1	Max.	
	Avg.	155	161	165	84.0	84.0	86.0	61.7	681	421	9.8	21.3	16.3	12.0	5.44	1.3	1.00	3.3	530	8.5	Avg.	
N	Min.	196	223	228	82.0	89.0	90.0	134.5	1675	864	13.0	27.0	16.0	18	10+	2.0	2.50	3.8	399	11.5	Min.	N
	Max.	207	228	235	92.0	96.0	96.0	145.0	2060	1018	14.0	35.0	17.0	18	10+	2.5	3.00	6.3	12479	12.9	Max.	
	Avg.	203	226	232	89.0	92.0	93.0	139.8	1907	922	13.5	30.7	16.7	18.0	10+	2.3	2.75	5.0	6546	12.3	Avg.	
O	Min.	156	163	170	79.0	81.0	84.0	52.6	592	414	9.5	19	14.0	12	4.76	1.3	1.00	2.7	260	6.8	Min.	O
	Max.	156	163	174	84.5	83.0	86.0	62.1	642	460	9.5	23	15.0	12	4.99	1.3	1.00	2.9	702	9.7	Max.	
	Avg.	156	163	172	82.0	82.0	85.0	61.1	615	433	9.5	21	14.7	12.0	4.91	1.3	1.00	2.8	515	8.3	Avg.	
Q	Min.	187	187	179	86.5	87.0	85.0	82.0	932	578	13.5	28	23	14	5.62	1.5	1.00	4.0	2573	10.4	Min.	Q
	Max.	196	196	196	90.0	89.5	91.5	86.8	1002	587	14.0	30	26	16	6.80	1.9	7.00	4.1	5220	13.3	Max.	
	Avg.	192	190	186	89.0	88.5	89.0	84.2	963	582	13.8	29.3	24	15.0	6.18	1.7	3.00	4.1	3912	11.7	Avg.	
R	Min.	196	196	192	90.5	90.0	93.0	43.5	482	388	12.0	26	18.0	12	4.19	1.3	0.75	2.9	1596	11.3	Min.	R
	Max.	196	196	196	94.0	96.0	97.0	63.7	712	528	12.5	28	19.0	16	4.95	1.5	1.00	3.2	2152	17.4	Max.	
	Avg.	196	196	194	92.0	93.0	95.0	63.3	707	517	12.2	27	18.7	14.0	4.37	1.4	0.92	3.1	1925	13.3	Avg.	
S	Min.	192	187	196	89.0	90.0	91.0	58.0	489	431	10.5	23	16	10	5.11	1.5	1.00	3.1	3388	7.6	Min.	S
	Max.	192	187	196	91.5	93.0	95.0	64.2	628	455	11.0	27	19	12	6.08	1.7	1.00	3.4	6614	10.0	Max.	
	Avg.	192	187	196	90.5	91.5	93.0	61.7	602	440	10.8	25	18	11.5	5.75	1.6	1.00	3.2	5347	8.9	Avg.	
T	Min.	187	187	202	11.0	91.0	91.0	45.1	391	283	10.5	18	7	14	......	......	......	......	......	......	Min.	T
	Max.	196	228	286	93.0	100.0	108.0	60.2	732	712	15.5	34	20	18	......	......	......	......	......	......	Max.	
	Avg.	192	207	238	68.0	95.5	98.7	50.7	586	478	12.6	28.3	13	16.0	......	......	......	......	......	......	Avg.	
U	Min.	149	143	149	70.0	76.0	76.0	37.0	435	328	7.5	16	12.0	10	3.58	1.0	0.75	2.6	405	4.6	Min.	U
	Max.	163	149	149	82.0	81.0	81.0	49.0	504	360	8.5	19	15.0	10	3.73	1.2	0.75	2.7	2257	6.8	Max.	
	Avg.	155	146	149	77.5	78.0	79.0	42.4	501	339	7.8	17.3	13.7	10.0	3.65	1.1	0.75	2.6	1331	5.6	Avg.	
V	Min.	262	262	255	99.0	100.0	100.0	44.0	369	356	12.0	30	16.0	12	3.81	1.5	0.75	2.5	3176	9.6	Min.	V
	Max.	277	269	269	103.0	103.0	102.0	65.0	580	441	13.5	31	24.0	14	5.20	2.0	1.00	2.9	8347	13.8	Max.	
	Avg.	270	266	262	101.5	101.5	101.5	55.1	580	391	13.2	30.3	20.3	13.0	4.42	1.8	0.92	2.7	6461	12.0	Avg.	
W	Min.	137	137	146	68.0	70.0	66.0	50.5	475	326	8.0	16	11.0	8	4.00	1.1	0.75	2.6	352	5.0	Min.	W
	Max.	143	140	146	76.0	77.0	82.0	52.5	576	381	8.5	19	14.0	10	4.38	1.2	1.00	3.0	617	6.8	Max.	
	Avg.	140	139	146	72.0	74.0	75.0	51.2	510	376	8.2	18	12.7	9.0	4.19	1.1	0.83	2.8	478	6.0	Avg.	
X	Min.	109	118	124	55.0	65.0	62.0	119.0	1097	1010	11.0	27	20.0	14	8.30	1.7	7+	3.6	......	5.4	Min.	X
	Max.	121	121	126	68.0	70.0	77.0	139.4	1142	1118	13.5	29	33.0	18	10.00	2.0	7+	3.7	......	10.9	Max.	
	Avg.	117	120	126	61.0	68.0	68.0	128.7	1120	1054	12.3	28	24.0	16.0	9.50	1.9	7+	3.6	......	7.7	Avg.	
Y	Min.	187	212	212	92.0	93.0	92.0	53.4	489	330	10.0	22	18.0	12	3.72	1.2	0.50	2.1	3757	7.2	Min.	Y
	Max.	207	217	217	95.5	96.0	95.5	59.2	663	389	13.5	24	19.0	12	4.01	1.3	0.75	2.7	7190	7.8	Max.	
	Avg.	199	215	215	94.0	94.0	94.0	56.8	563	358	12.0	23	18.3	12.0	3.86	1.3	0.67	2.3	5216	7.5	Avg.	
Z	Min.	228	228	228	97.0	95.0	94.0	137.9	1562	920	20.5	46	17.0	24	7.69	1.5	1.00	4.0	13568	17.7	Min.	Z
	Max.	241	241	241	99.0	100.0	99.0	139.4	1678	953	22.5	47	33.0	24	8.83	2.0	7+	4.2	22630	21.8	Max.	
	Avg.	231	236	236	98.0	97.0	96.0	138.8	1632	935	21.4	47	28.0	24.0	8.16	1.7	3	4.1	19235	19.7	Avg.	

Impact Tests on Small Specimens:

Charpy.—The unnotched Charpy test was made by A. L. Boegehold in the General Motors Research Laboratory. The specimen was 0.394 in. square by 2.1 in. long. The data on the machine are shown in Table I. Notched Charpy tests were made by F. B. Coyle at the research laboratory of the International Nickel Co., using the standard specimen shown in Fig. 2 (No. 4). The machine is the regular Amsler construction with a pendulum of 44 lb. and a maximum capacity of 240 ft-lb. The other details were not known by the International Nickel Co. engineers.

Izod.—Unnotched Izod tests were made by M. L. Enger at the University of Illinois. The specimen was a rectangular cross-section 0.50 by 0.75 in. and 3¼ in. long. Enger comments as follows: "We have found it necessary to make the rear support lower than the front support (by rear support is meant the one at the struck face of the specimen) by about ¼ in. Before we made this modification we had occasional very high readings because the failure occurred below the top of the rear jaw and a large amount of work was required to pull the specimen free." This arrangement is shown in Fig. 8 and the details of the machine are shown in Table I.

Notched Izod tests were made by F. N. Menefee at the University of Michigan. The specimen is shown in Fig. 2 (No. 2) and the details of the machine are shown in Table I.

Tension impact tests were made at the Bureau of Standards using the specimen shown in Fig. 2 (No. 3), the 224-ft-lb. Charpy machine shown in Fig. 9, with the adapter shown in Fig. 10. The data on the machine are given in Table I.

Repeated-Blow Test:

This test—the Krupp-Stanton test—was made by the British Cast Iron Research Association using the specimen shown in Fig. 2 (No. 5). The distance between supports is 100 mm. The specimen is rotated 180 deg. after each blow. The height of drop is 1.2 in., the weight of the hammer 4.81 lb. The machine strikes 84 blows per minute.

Transverse Test for "Set":

One standard 1.20 by 21-in. bar of each set was subjected to repeated-loading tests to determine the plastic deformation at 20, 40, 60 and 80 per cent of its average transverse strength. This was done in the 5000-lb. Riehle autographic transverse machine. A frame with 18-in. supports was constructed with an Ames dial, graduated in thousandths of an inch, at the center. Each bar was placed in the frame before testing and the reading of the dial recorded. The exact position of the supports was marked on the bar, and each loading and reading was done with the bar in the same position. The bar was then loaded twenty-five times to each point and the amount of permanent deflection read by returning the bar to the frame after the first, second, third, fifth, tenth, fifteenth, twentieth and twenty-fifth loading. Load-deflection curves were also obtained for each of these loadings.

PRESENTATION OF RESULTS

The results of the physical tests are listed in Tables III and IV, and the casting data and average chemical analysis are listed in Table II. Minimum, maximum and average physical-test values are shown and as most of the tests were made on three specimens the third result can be easily calculated by subtracting the sum of the maximum and minimum from three times the average. In some cases a wild result was omitted from the average but these will be apparent, as for example the drop test No. 2 on iron A when the minimum is 14, the maximum 20, and the average 20. The two values of 20 were consistent with the results of the other tests, so the 14-in. result was not averaged. Iron T showed a tendency to develop shrinkage cavities in the center which ruined it for small specimens. Quite a few bars of iron X showed the same tendency, and there was not enough good material for the Krupp-Stanton specimens. One iron, T, showed a very great difference in structure between the first flask and the last. It will be noted that the deflection, resilience, hardness and drop tests are all wild on this iron. Analysis showed that the first flask had 1.65 per cent combined carbon (heavily mottled) and the last flask only 1.11 per cent (very slightly mottled). No other iron showed this extreme sensitiveness, which is frequently encountered in the low-silicon irons. The metal, of course, was not intended for a section such as the test bar used.

Modulus of rupture and modulus of elasticity as used here in the transverse test are calculated from the conventional beam formulas:

$$\text{Modulus of rupture, } f = \frac{P\,l\,c}{4\,I} \text{ and}$$

$$\text{Modulus of elasticity, } E = \frac{P\,l^3}{48\,D\,I}$$

by substituting load for P and deflection for D.

For tension and compression the following was used:

$$\text{Modulus of elasticity, } E = \frac{\text{unit stress}}{\text{unit strain}}$$

TABLE V.—PERMANENT SET IN BENDING TEST.

Iron	Load, per cent of total load	Set, in.								Final Set, per cent
		First Loading	Second Loading	Third Loading	Fifth Loading	Tenth Loading	Fifteenth Loading	Twentieth Loading	Twenty-fifth Loading	
A	20	0.002	0.0024	0.0026	0.001	0.0026	0.003	0.0025	0.0023	6.4
	40	0.0053	0.007	0.0074	0.008	0.007	0.0085	0.008	0.0081	10.7
	60	0.017	0.0178	0.018	0.0193	0.020	0.0202	0.021	0.0212	17.0
	80	0.032	0.035	0.037	......	0.0406	0.041	0.043	0.0435	22.9
B	20	0.001	0.0014	0.0014	0.0013	0.0018	0.0021	0.001	0.002	5.4
	40	0.0058	0.0061	0.0066	0.007	0.0077	0.0076	0.0076	0.0079	10.1
	60	0.0155	0.0165	0.017	0.018	0.019	0.0159	0.017	0.017	13.3
	80	0.0319	0.0332	0.0382	0.040	0.0427	0.046	0.047	0.048	25.0
C	20	0.002	0.002	0.002	......	0.004	0.004	0.004	0.004	12.1
	40	0.009	0.010	0.010	......	0.010	0.010	0.014	0.014	18.2
	60	0.025	0.028	0.028	......	0.032	0.033	0.034	0.0345	25.0
	80	0.060	0.065	0.067	0.0717	0.076	0.0785	0.079	0.081	37.3
D	20	0.0005	0.0010	0.0010	......	0.0012	0.0005	0.0005	0.0005	2.2
	40	0.0025	0.0028	0.0025	......	0.0030	0.0027	0.0025	0.0030	6.7
	60	0.0055	0.0062	0.0064	0.0065	0.0070	0.0071	0.0073	0.0076	10.6
	80	0.0095	0.0105	0.0105	0.0125	0.0125	0.0135	0.0115	0.0135	13.5
E	20	0.0013	0.0015	0.0017	0.0018	0.002	0.002	0.0017	0.002	5.7
	40	0.005	0.006	0.006	......	0.007	0.007	0.007	0.007	9.0
	60	0.013	0.014	0.015	......	0.016	0.016	0.016	0.017	13.1
	80	0.031	0.033	0.035	......	0.038	0.040	0.040	0.040	20.2
F	20	0.001	0.0014	0.0016	......	0.0015	0.0016	0.0017	0.0016	5.3
	40	0.004	0.005	0.0055	......	0.006	0.006	0.0062	0.0064	9.6
	60	0.0122	0.0130	0.0135	0.014	0.0152	0.0152	0.0158	0.0160	14.3
	80	0.027	0.0293	0.0310	0.0317	0.0348	0.0360	0.0370	0.0380	22.5
G	20	0.002	0.002	0.002	......	0.003	0.003	0.003	0.003	7.5
	40	0.007	0.008	0.008	......	0.009	0.009	0.010	0.010	11.5
	60	0.017	0.018	0.019	......	0.021	0.022	0.022	0.023	15.3
	80	0.039	0.042	......	0.045	0.0485	0.0495	0.051	0.0523	24.5
H	20	0.001	0.001	......	......	0.001	0.001	0.001	0.001	3.0
	40	0.0035	0.004	0.004	......	0.0046	0.005	0.005	0.005	7.1
	60	0.0095	0.0105	0.011	......	0.0113	0.012	0.012	0.012	10.5
	80	0.021	0.023	0.025	......	0.027	0.028	0.0285	0.0285	16.6
I	20	0.001	0.002	0.002	......	0.0025	0.003	0.0025	0.003	9.4
	40	0.006	0.007	0.007	......	0.008	0.007	0.009	0.009	13.0
	60	0.018	0.019	0.020	......	0.020	0.022	0.023	0.024	21.1
	80	0.044	0.046	0.048	0.049	0.052	0.054	0.056	0.057	31.7
J	20	0.001	0.001	0.001	......	0.001	0.001	0.001	0.001	2.6
	40	0.003	0.004	0.004	......	0.0047	0.005	0.0048	0.005	6.1
	60	0.009	0.009	......	......	0.011	0.011	0.011	0.011	8.1
	80	0.019	0.021	0.023	......	0.025	0.026	0.0266	0.027	13.6
K	20	0.0015	0.0018	0.0020	0.0022	0.0020	0.0025	0.0025	0.0025	6.9
	40	0.0055	0.0060	0.0065	......	0.0065	0.0070	0.0075	0.0075	9.3
	60	0.0125	0.0135	0.0145	0.0145	0.0158	0.0160	0.0160	0.0165	12.3
	80	0.0275	0.0297	0.0308	0.0325	0.0341	0.0355	0.0359	0.0365	18.8
L	20	0.0013	0.0013	0.0013	......	0.0016	0.0015	0.0015	0.0017	4.5
	40	0.0051	0.0054	0.0054	......	0.006	0.0062	0.0062	0.0062	7.3
	60	0.0117	0.0122	0.013	......	0.014	0.0145	0.015	0.0155	11.0
	80	0.026	0.0285	0.030	0.031	0.033	0.0345	0.035	0.0355	16.7
M	20	0.0015	0.0015	......	......	0.002	0.002	0.0022	0.0022	6.7
	40	0.0075	0.0084	0.0086	......	0.011	0.011	0.011	0.0113	14.7
	60	0.0205	0.022	0.023	......	0.025	0.026	0.026	0.026	19.9
	80	0.048	0.0515	0.054	0.056	0.060	0.062	0.063	0.064	30.8
N	20	0.003	0.0035	0.0033	......	0.003	0.0036	0.004	0.0038	9.3
	40	0.0156	0.0163	0.017	......	0.018	0.0182	0.0185	0.0187	19.1
	60	0.043	0.0449	0.046	0.0475	0.0485	0.0495	0.050	0.0503	27.5
	80	0.0966	0.100	0.102	0.1045	0.1062	0.107	0.108	0.1085	36.8
O	20	0.003	0.003	0.003	......	0.0035	0.0033	0.0035	0.0033	10.0
	40	0.007	0.008	0.008	......	0.013	0.013	0.0135	0.014	18.0
	60	0.0195	0.021	0.022	......	0.024	0.0245	0.025	0.0255	19.0
	80	0.047	0.051	0.0535	......	0.031	0.033	0.035	0.0355	39.0

TABLE V.—(*Continued*).

Iron	Load, per cent of total load	Set, in.								Final Set, per cent
		First Loading	Second Loading	Third Loading	Fifth Loading	Tenth Loading	Fifteenth Loading	Twentieth Loading	Twenty-fifth Loading	
Q	20	0.001	0.001	......	......	0.001	0.001	0.001	0.001	2.5
	40	0.004	0.0043	0.0045	......	0.0055	0.0057	0.0058	0.0060	7.1
	60	0.015	0.017	0.0173	......	0.0193	0.020	0.0208	0.021	14.6
	68	0.030	0.0327	0.0337	0.0352	0.0372	0.0387	0.039	0.040	22.6
	80	0.0706	0.079	0.0815	......	0.090	0.093	0.095	0.097	34.7
R	20	0.0015	0.0019	0.0015	......	0.002	0.002	0.002	0.002	5.6
	40	0.0053	0.006	0.006	......	0.0065	0.007	0.007	0.007	8.9
	60	0.0153	0.0163	0.017	......	0.019	0.0194	0.020	0.021	15.7
	80	0.043	0.046	0.049	0.052	0.055	0.056	0.057	0.058	28.0
S	20	0.0014	0.0017	0.0016	0.0016	0.0015	0.0018	0.0021	0.0021	7.0
	40	0.0046	0.0046	0.0054	0.0060	0.0061	0.0062	0.0069	0.0069	10.0
	60	0.0131	0.0141	0.0151	0.0158	0.0161	0.0171	0.0171	0.0171	15.7
	80	0.0275	0.0311	0.0331	0.0351	0.0371	0.0381	0.0384	0.0391	21.7
U	20	0.003	0.0037	0.004	......	0.004	0.0043	0.0043	0.0047	13.4
	40	0.011	0.0118	0.012	......	0.013	0.013	0.0133	0.0133	15.7
	60	0.025	0.026	0.0267	0.027	0.029	0.030	0.0355	0.031	20.3
	80	0.050	0.0535	0.0552	......	0.0612	0.0625	0.064	0.065	27.9
V	20	0.001	0.001	......	......	0.001	0.001	0.0012	0.0013	3.7
	40	0.0025	0.0025	......	......	0.003	0.003	0.003	0.003	4.0
	60	0.005	0.006	0.006	......	0.0068	0.007	0.0068	0.007	6.0
	80	0.0125	0.0135	0.014	......	0.016	0.016	0.0165	0.017	10.2
W	20	0.002	0.002	......	......	0.0025	0.0025	0.0025	0.003	9.4
	40	0.006	0.007	0.010	0.011	0.014	0.015	0.0155	0.016	21.0
	60	0.030	0.0315	0.0325	......	0.035	0.036	0.0365	0.037	27.4
	80	0.055	0.068	0.070	0.074	0.0775	0.080	0.082	0.083	38.1
X	20	0.0015	0.002	0.002	......	0.002	0.0025	0.0025	0.0025	8.3
	40	0.010	0.0107	0.011	......	......	0.013	0.013	0.0132	17.4
	60	0.0375	0.0395	0.0422	0.0438	0.046	0.0465	0.047	0.0472	31.0
	80	0.1299	0.1372	0.1415	0.1478	0.1515	0.1538	0.154	0.1547	51.9
Y	20	0.001	0.001	......	......	0.0015	0.002	0.002	0.002	4.9
	40	0.005	0.005	......	......	0.0065	0.0065	0.007	0.007	8.3
	60	0.013	0.014	0.0144	......	0.016	0.017	0.017	0.0175	13.0
	80	0.035	0.037	0.039	......	0.043	0.045	0.046	0.0465	22.8
Z	20	0.0015	0.0015	......	......	0.002	0.002	0.002	0.002	4.4
	40	0.0052	0.006	0.006	......	0.007	0.007	0.007	0.007	6.7
	60	0.0163	0.018	0.019	0.020	0.0217	0.0226	0.023	0.023	12.9
	80	0.055	0.061	0.064	0.067	0.0715	0.0745	0.0765	0.078	28.0

The committee is fully aware of the objections to this procedure, but uses these values as convenient indexes of strength and stiffness, respectively.

Figure 11 shows the transverse bending curves (average load at each 0.05 in. deflection to breaking, where the average load is plotted against the average deflection) for each set.

Figures 12 and 13 show the behavior of the various irons in the repeated loading test. The curves reproduce, as accurately as could be read, the *first* loading to each point after the 25 loadings to the previous point. The deflection at 20 per cent on the first loading to 20 per cent was taken as the reference point for plotting the first loading to 40 per cent and so on. To illustrate: If the deflection at the first loading to 20 per cent was 0.05 in. and the deflection at this

TABLE VI.—RELATIVE MODULUS OF ELASTICITY AT ONE-FOURTH THE BREAKING STRENGTH OF THE SEVERAL TESTS.

	RELATIVE MODULUS OF ELASTICITY, LB. PER SQ. IN.			
IRON	TRANSVERSE TEST, 1.20 BY 18-IN. BAR	TRANSVERSE TEST, 0.5 BY 5-IN. BAR	TENSION TEST, 0.505-IN. DIAM. BAR	COMPRESSION TEST, 1.20-IN. DIAM. BAR
A	15.9	13.7	13.6	13.9
B	14.3	12.8	12.5	14.7
C	10.4	8.2	9.1	8.3
D	13.3	10.2	12.5	14.1
E	17.4	15.1	16.8	16.7
F	14.2	10.3	12.0	12.1
G	14.4	12.8	12.5	14.5
H	16.7	17.7	14.5	15.0
I	12.8	9.4	11.1	10.7
J	19.1	17.7	18.6	17.7
K	16.2	13.8	15.0	14.6
L	17.9	15.7	16.7	15.5
M	14.6	10.2	13.3	10.2
N	13.2	11.5	9.9	9.8
O	14.6	11.9	13.0	12.0
Q	19.1	17.3	16.7	18.2
R	17.8	16.1	15.7	15.8
S	17.9	14.1	15.0	14.5
T	19.9	....	17.8	16.2
U	11.1	9.3	8.8	8.4
V	22.6	19.5	20.9	21.1
W	11.9	9.8	9.8	8.9
X	14.5	9.8	12.0	10.0
Y	16.5	16.1	15.0	15.0
Z	19.9	18.5	18.7	19.5

TABLE VII.—MICROSTRUCTURAL RATING.

Sample X (austenitic) and N (martensitic) not considered in the table.

Order of Merit	Graphite	Steadite	Pearlite		Ferrite	Composite Rating
			Lamination Fineness	Grain Size		
1	C	D	F	D	T	F 15
2	U	F	I	C	V	D 19
3	W	A	H	F	I	I 26
4	D	B	E	H	F	H 28
5	F	I	D	I	H	A 37
6	G	E	T	U	M	B 40
7	B	H	A	A	O	T 45
8	A	Q	B	B	D	E 47
9	H	R	K	K	E	C 48
10	V	Y	R	W	Q	U 62
11	I	T	M	G	Y	G 62
12	E	O	C	Y	A	O 62
13	T	G	Q	O	B	W 64
14	O	K	W	T	C	K 64
15	R	L	G	M	K	M 66
16	S	M	O	E	U	Y 70
17	K	S	U	V	G	V 71
18	M	W	Y	S	S	R 73
19	Y	C	L	R	W	Q 75
20	L	J	V	L	R	S 91
21	J	U	J	J	L	L 95
22	Q	V	S	Q	Z	J 106
23	Z	Z	Z	Z	J	Z 113

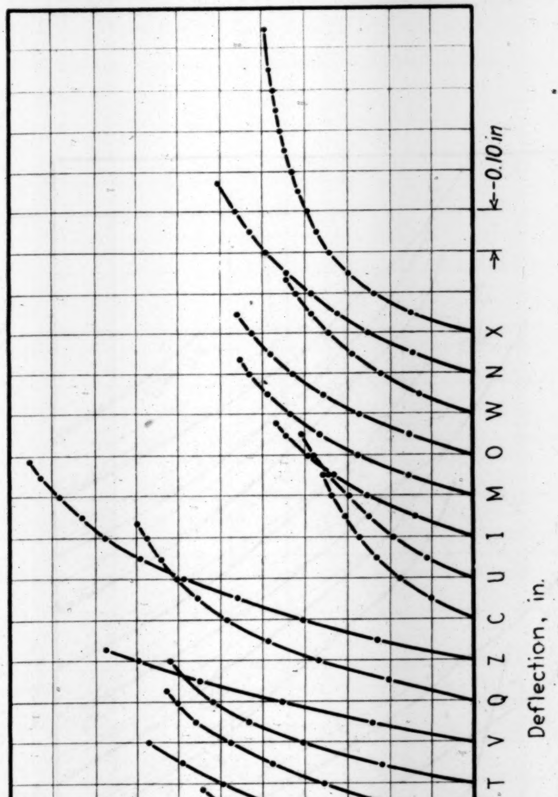

FIG. 11.—Transverse Bending Curves.

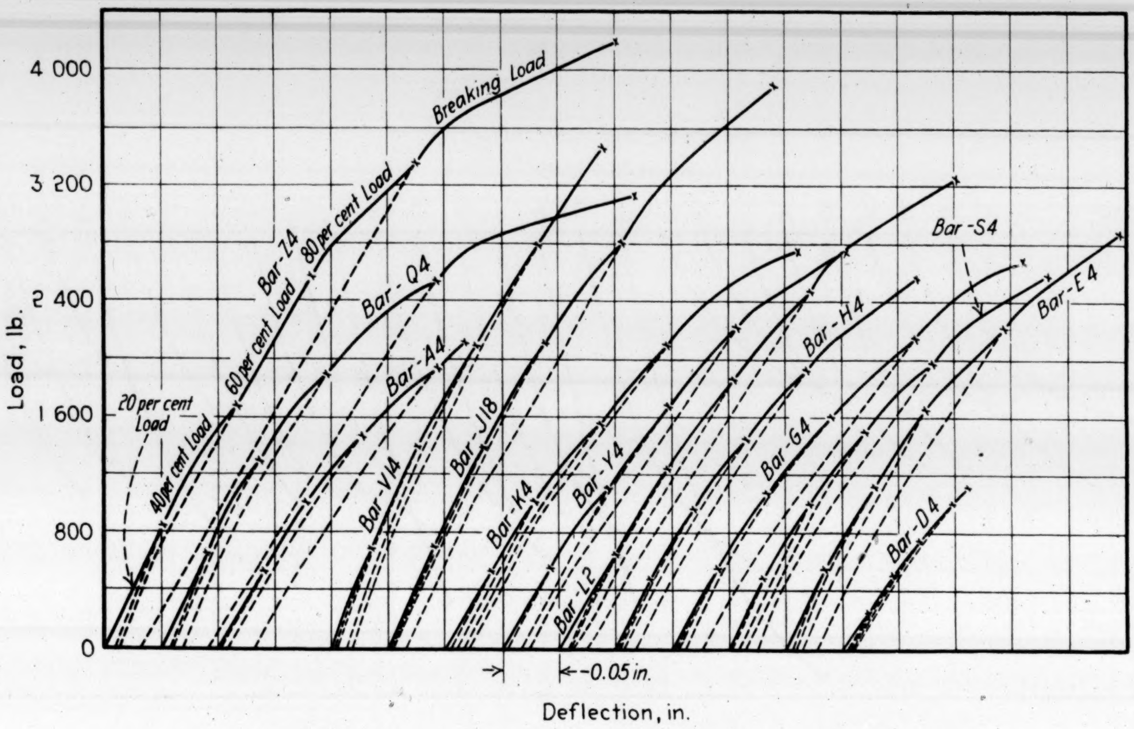

FIG. 12.—Effect of Repeated Loading on the Load-Deflection Curves of Cast Iron.

Twenty-five repetitions at intervals of 20 per cent up to 80 per cent load. Curve shows first loading to each point to one final loading to rupture.

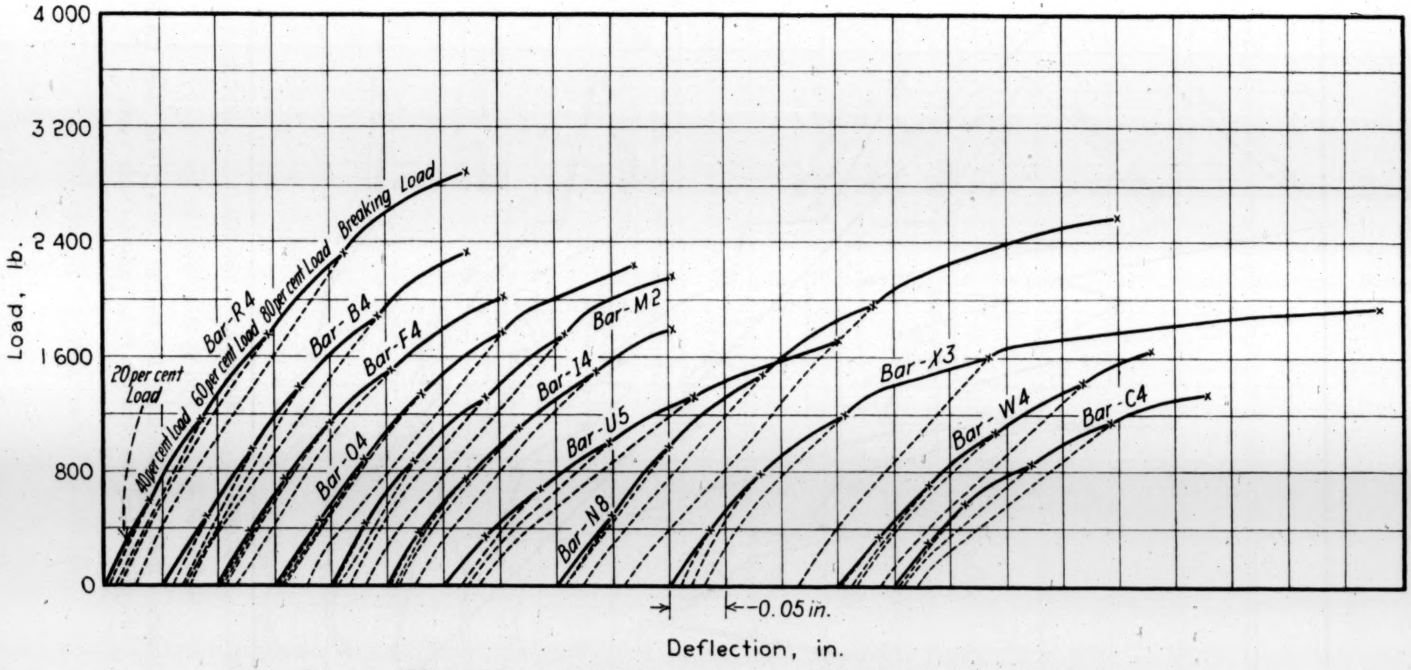

FIG. 13.—Effect of Repeated Loading on the Load-Deflection Curves of Cast Iron.

Twenty-five repetitions at intervals of 20 per cent up to 80 per cent load. Curve shows first loading to each point to one final loading to rupture.

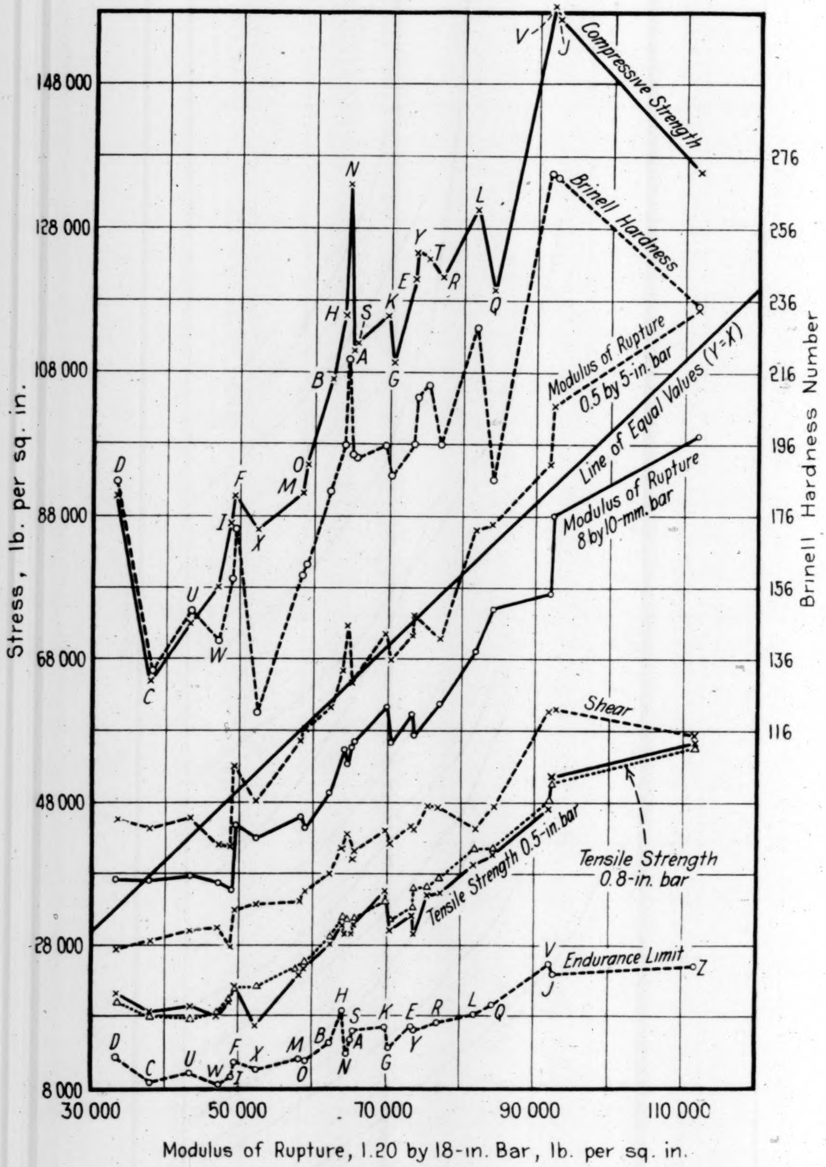

FIG. 14.—Relation Between Modulus of Rupture of 1.20 by 18-in. Bars, the Brinell Hardness, and the Strength from Various Other Tests.

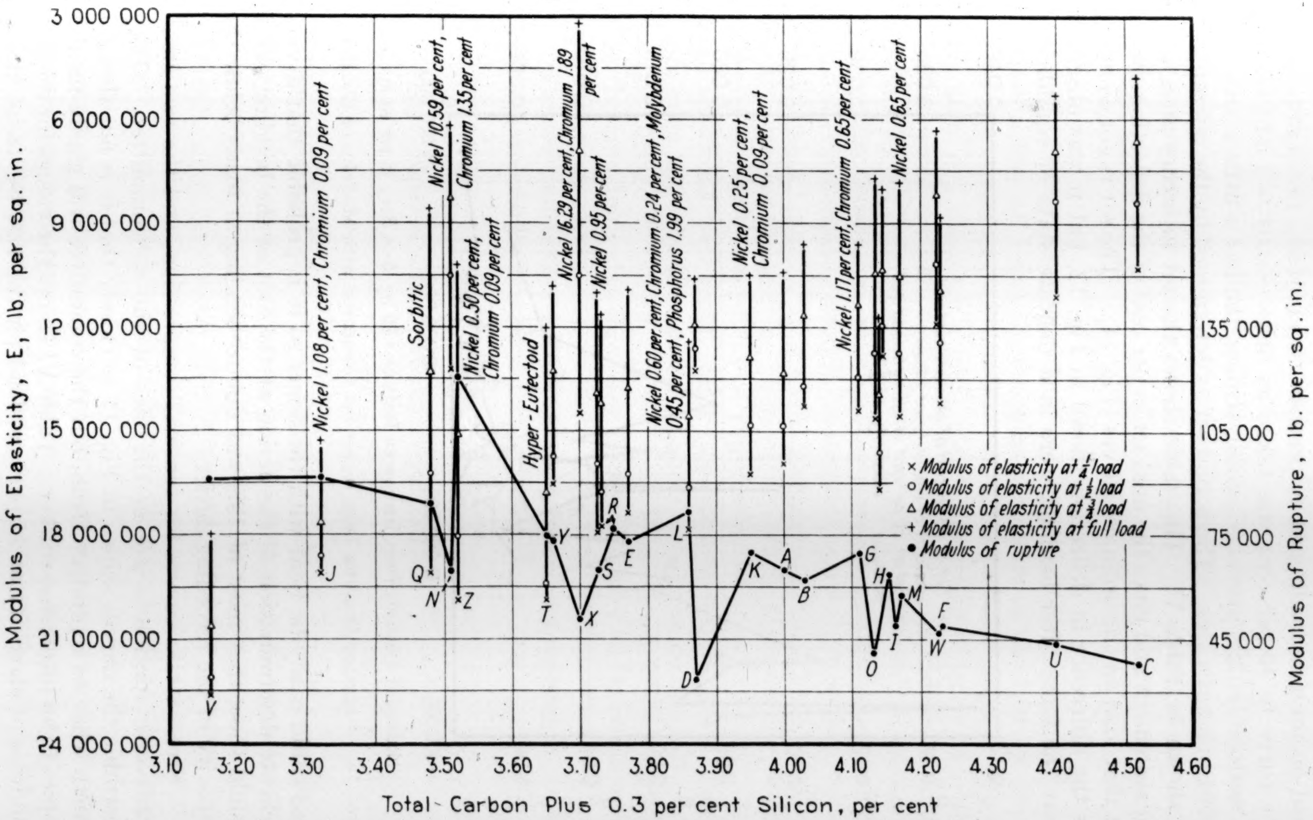

FIG. 15.—Comparison of Modulus of Elasticity at $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$ and Full Load on 1.20 by 18-in. Transverse Bar with the Composition of the Metal.

load on the first loading to 40 per cent was 0.04 in., the zero point of the curve to 40 per cent was taken as (0.05 − 0.04 =) 0.01 in. It is noticeable that previous loading stiffens the bar a little above that point in many cases. The actual set as determined by the micrometer is shown in Table V. This table shows the set in inches after each measurement and gives the final set in per cent of the deflection shown at that load on the ordinary curves (Fig. 11). The set is not so much as the difference in deflection shown in Fig. 12, but it was observed that the bars, after loading, were in a delicate state of equilibrium and could easily be bent with the finger so it is probable that a very delicate determination of the action at the foot of the bending curve would show that most of this was due to bending at loads below the capacity of the recording device.

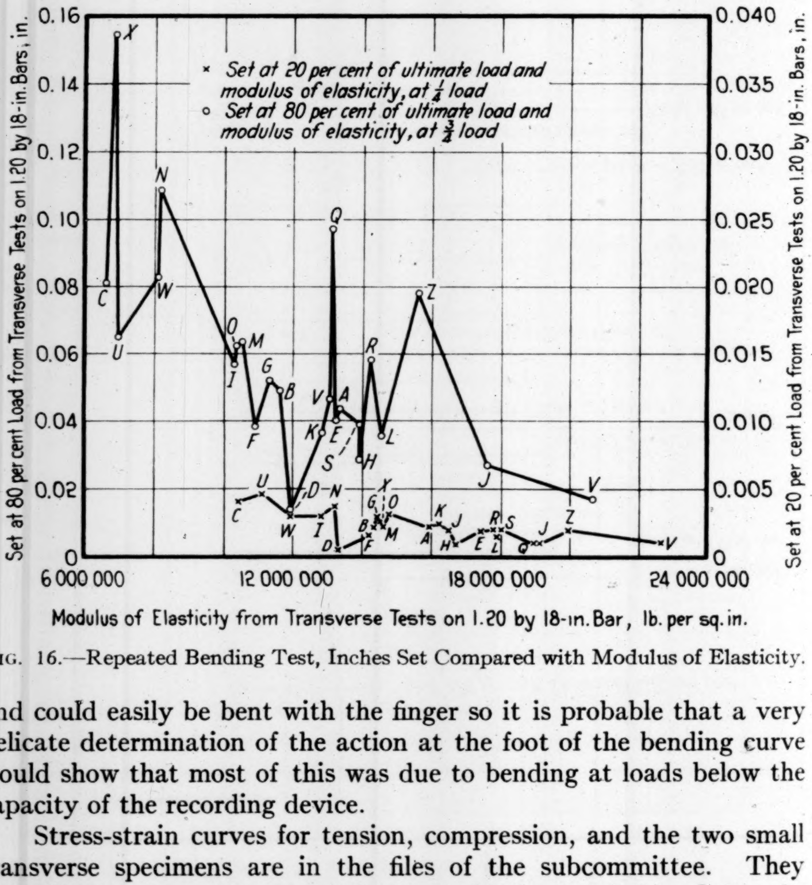

FIG. 16.—Repeated Bending Test, Inches Set Compared with Modulus of Elasticity.

Stress-strain curves for tension, compression, and the two small transverse specimens are in the files of the subcommittee. They resemble the curves shown in Fig. 11 so closely that it is not thought worth while to reproduce them, but the committee will gladly furnish copies to an interested worker. Table VI shows the values for relative modulus of elasticity at 25 per cent load for the 1.20 by 18-in. transverse test, the 0.5 by 5-in. transverse test, the 0.505-in. tension test, and 1.20 by 4-in. compression test.

The average modulus of elasticity for tension and transverse tests on the same size specimens ($\frac{1}{2}$ in.) agree within 3 per cent. The average compression value is 87.5 per cent of the average transverse value of the same size.

CORRELATION OF RESULTS

The various strength values and Brinell hardness numbers are plotted in Fig. 14, using the modulus of rupture of the 1.20 by 18-in. bar as the common comparison. An extended discussion is out of place here, but there are a great many interesting differences in the performance of the various irons in the several tests which are easily explained by the difference in section and the structure of the specimen used. The correlation between compressive strength and Brinell hardness is remarkable—iron X (austenitic) exhibiting the only important difference. Iron D (2 per cent phosphorus) had a hard, unyielding structure for the working fibers of the 1.20-in. diameter bar, which accounts for its low modulus of rupture in the standard bar. The small specimens were much softer (see hardness values in Table IV), hence gave better results, except in shear, while the compression test was not affected by this structure. Irons V and J, which were slightly over the eutectoid, also show low results on the 1.20-in. modulus of rupture.

The relation between Rockwell and Brinell hardnesses is found (least squares) to be:

$$\text{BHN} = \frac{8030}{132 - R_{B\frac{1}{16}}}$$

This compares with Petrenko's equation of:

$$\text{BHN} = \frac{7300}{130 - R_{B\frac{1}{16}}}$$

As mentioned above, the scatter on the Rockwell readings is very annoying on the soft irons, but it seems only fair to include all values, even very low ones, as was done in calculating the above equation. We believe our equation more useful for cast iron than Petrenko's, although the two curves are quite close together for the stronger irons. (The difference is 1.5 points Rockwell at 200 Brinell hardness.)

Only one comparison is given between analysis and other properties though many could be profitably shown. Figure 15 shows the stiffness at the quarter load points in the transverse test (1.20 by

18 in.) plotted against the total carbon, plus three-tenths of the silicon content and with unusual structures or alloy elements noted on the graph. The modulus of rupture is also drawn in to indicate the general relationship between these two properties. Again the high-phosphorus iron D, the martensitic iron N, and the austenitic iron X

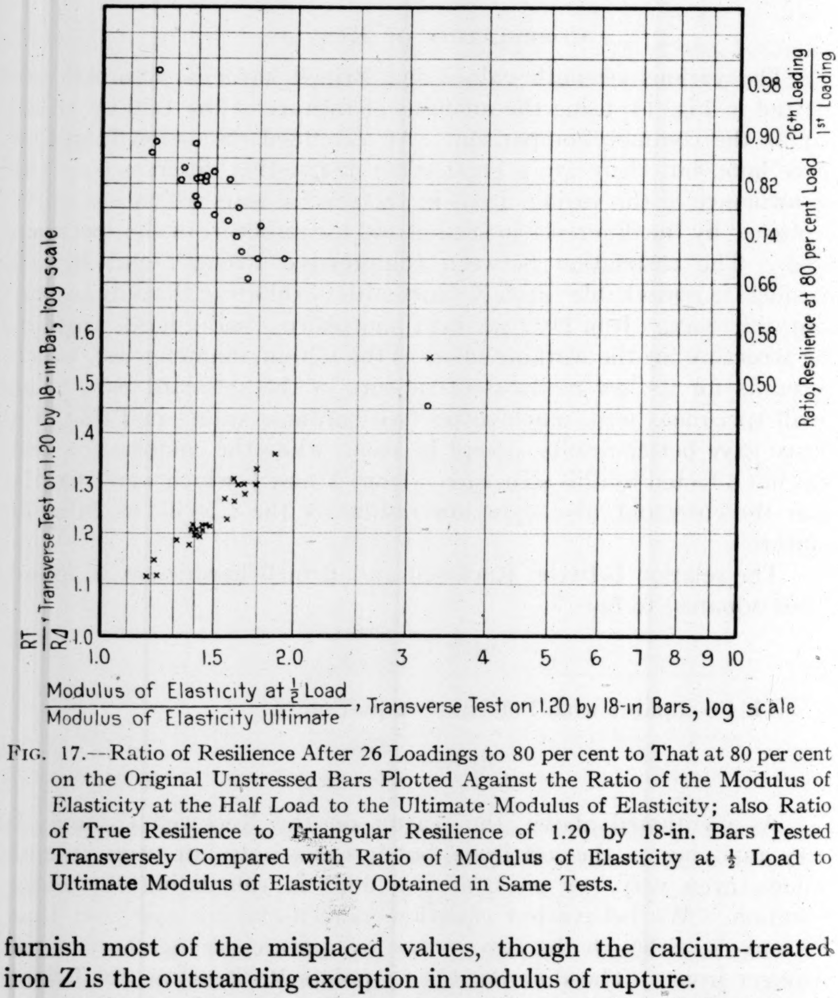

FIG. 17.—Ratio of Resilience After 26 Loadings to 80 per cent to That at 80 per cent on the Original Unstressed Bars Plotted Against the Ratio of the Modulus of Elasticity at the Half Load to the Ultimate Modulus of Elasticity; also Ratio of True Resilience to Triangular Resilience of 1.20 by 18-in. Bars Tested Transversely Compared with Ratio of Modulus of Elasticity at ½ Load to Ultimate Modulus of Elasticity Obtained in Same Tests.

furnish most of the misplaced values, though the calcium-treated iron Z is the outstanding exception in modulus of rupture.

An interesting comparison of set with modulus of elasticity is shown in Fig. 16. Again irons X, N, D and Z stand out boldly, while iron Q, a sorbitic iron with a highly curved load-deflection graph, shows low set at low load but high set at high load.

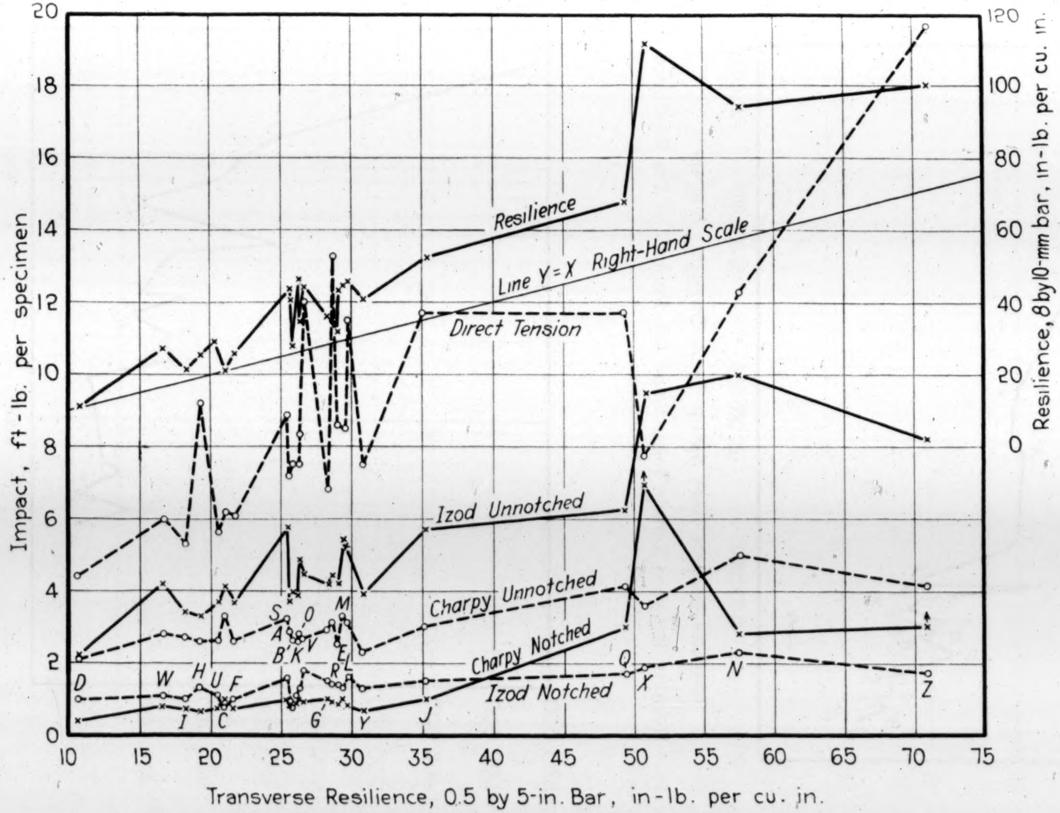

FIG. 18.—A.T.F. Resilience and Swing Through Impact on Small Bars Compared with Transverse Resilience on 0.5 by 5-in. Bars.

Arrow indicates at least one specimen unbroken at capacity of machine.

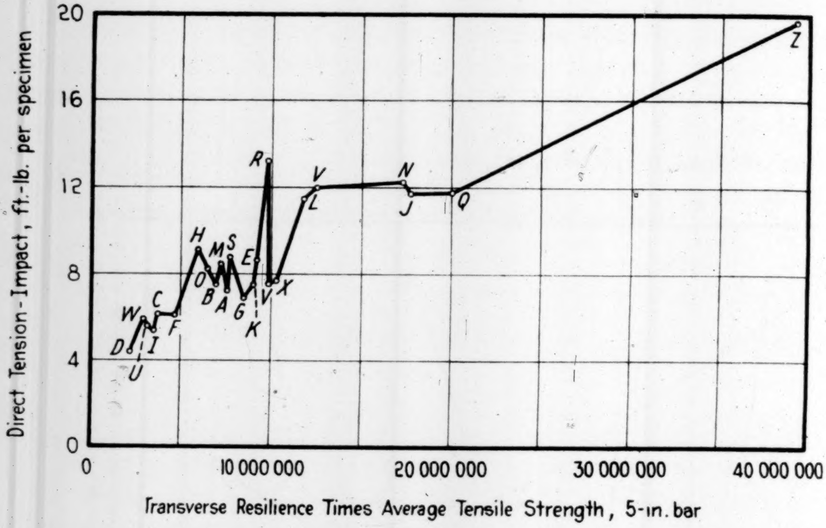

FIG. 19.—Relation Between Tensile Impact and the Product of the Resilience by the Strength.

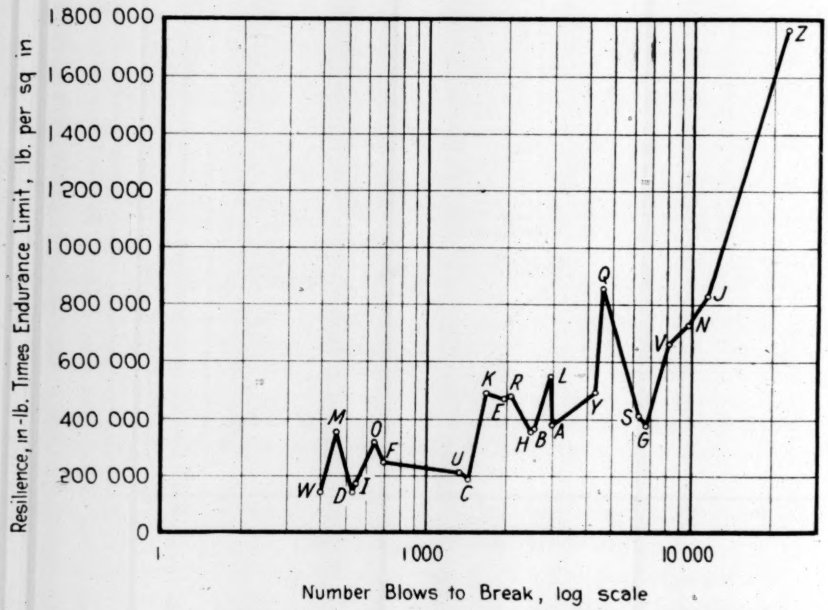

FIG. 20.—Ratio Repeated Blow Impact Test to Transverse Resilience Times Endurance Limit (0.5 by 5-in. Bar).

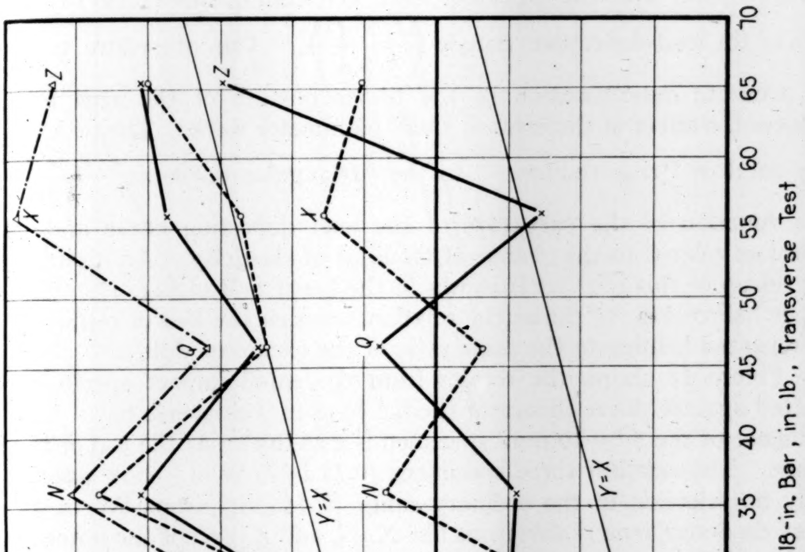

FIG. 21.—Energy of Pendulum Swing Through Impact Tests on 1.20-in Bars and Transverse Resilience of Small Bars Compared with Transverse Resilience of 1.20-in. Bars in Transverse Tests.

Resilience, or work done in breaking the bar, was determined for each bar by planing out the area lying above the line connecting the zero point with the breaking point, and adding this excess to the area of the load-deflection triangle $\left(\frac{L \times D}{2}\right)$. This procedure gives an accurate determination of the major portion of the area and reduces the effect of the error in small planimeter work. The ratio of this total or "true resilience" to the "triangular resilience" $\frac{L \times D}{2}$ is a function of the curvature of the load-deflection curve and is therefore related to the change of modulus of elasticity. An interesting set-up of this relation is shown in the lower half of Fig. 17. The upper half of Fig. 17 shows the relation between the loss of resilience on repeated loading to the same ratio of the elastic moduli.

Figure 18 shows the results from the small impact specimens plotted against the resilience of the 0.5 by 5-in. transverse bar. The resilience of the 8 by 10 mm. specimen is also drawn at the top of the figure. The smallest three specimens (0.39 by 0.39 in.) show practically no selection in the ordinary range of foundry irons (W to J). They do detect remarkable irons like X, N, and Z (except the notched Izod, which would not even detect Z). All except the notched Izod show iron D to be the most brittle. The unnotched Izod (Enger) test using a fairly large specimen (0.5 by 0.75 in.) begins to show distinct signs of correlation with resilience—in fact, its correlation with the transverse test on the 8 by 10-mm. bar, which was also rectangular, is quite good. The two irons, N and X, which tend to tear slowly apart are misplaced largely because of their behavior in the transverse test, where they generally cracked without breaking. The curves were dealt with just as the normal cast irons. If it were possible to measure the actual resilience of these irons it would probably lie beyond that of iron Z. Iron X is erratic in these small specimens on account of its tendency to shrink—a perfectly sound specimen being excellent while a small specimen with a shrink in it would show mediocre results.

The tensile impact is quite erratic. It appeared that, in general, the strong irons were above the median line and the weak irons were below it, therefore, Fig. 19 was drawn plotting the tensile impact against the product of resilience and strength. The correlation is not so poor as in Fig. 18, but is still not very striking.

The Krupp-Stanton test plotted against the product of resilience and endurance limit (Fig. 20) is the best correlation obtained of several tried and seems to be the most logical assumption. (The

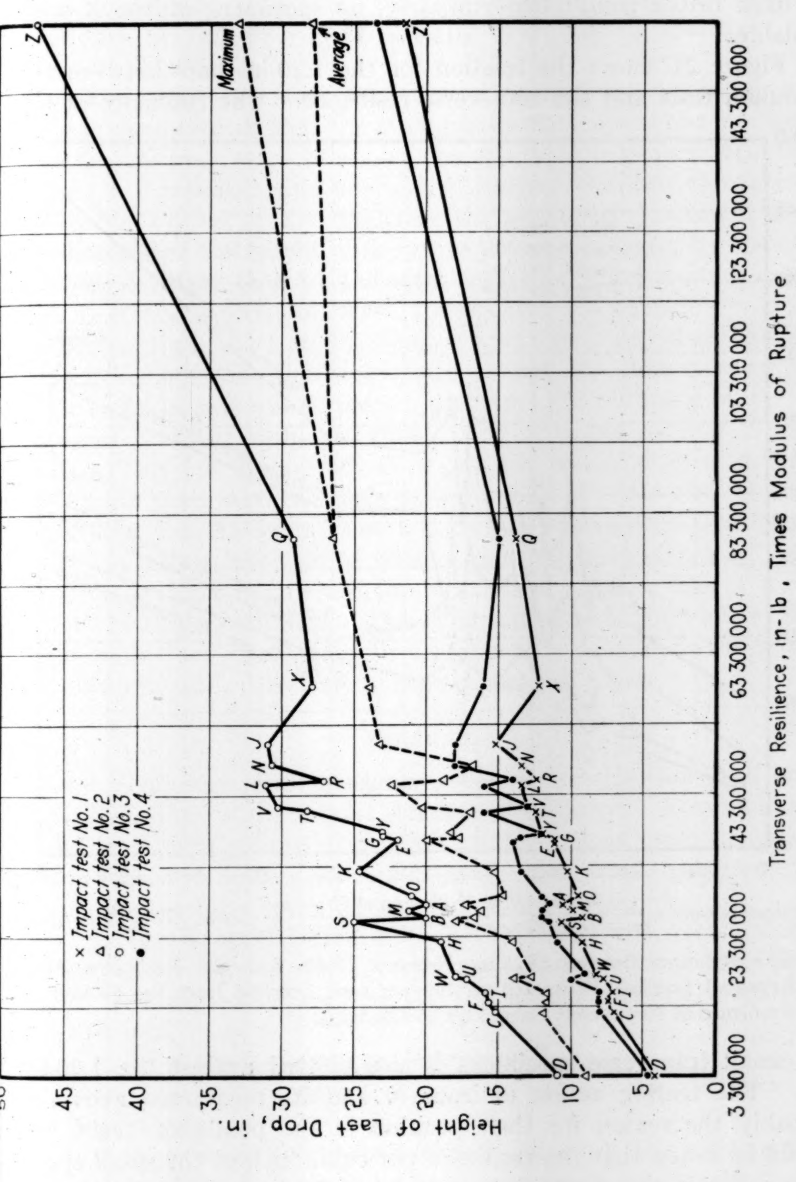

FIG. 22.—Falling Hammer Impact on 1.20-in. Bars in Inches Drop Compared with Transverse Resilience Times Modulus of Rupture of 1.20-in. Transverse Bars.

log scale for number of blows is simply for convenience.) This test is the only one except the notched Izod that does not show iron D as the most brittle iron. Unfortunately, no specimens of iron X were available.

Figure 21 shows the relation for the 1.20-in. bars between the pendulum tests and the transverse resilience. The resilience of the two small transverse specimens is also plotted against the 1.20-in. bar. The tearing action of irons N and X, mentioned above, is probably the reason for their position in the pendulum tests. It should be noted that the resilience per cubic inch of the small specimens is distinctly above that of the 1.20-in. bars; that the energy *used* in the pendulum test is greater than that *absorbed* in the trans-

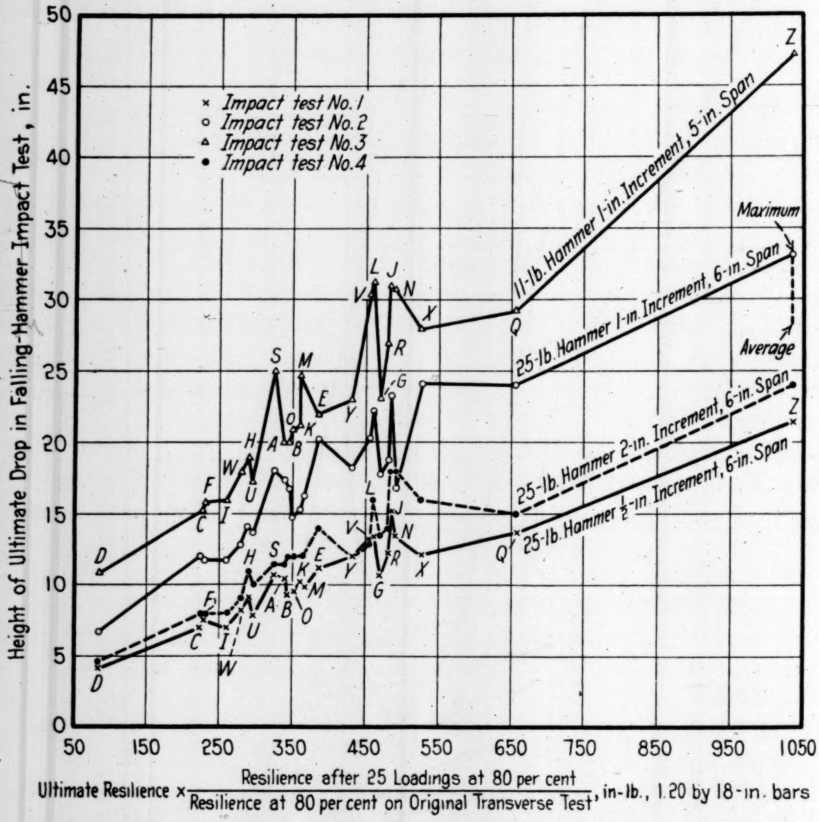

FIG. 23.—Relation Between Falling Hammer Tests and the Resilience After Repeated Loading Estimated to 100 per cent Loading from the Change in Resilience at 80 per cent Caused by 26 Loadings.

verse test; and that the 8-in. span Russell gives higher results than the 18-in. span, as would be expected from the known effect of span in increasing the "ultimate" modulus of elasticity and decreasing the modulus of rupture. The Charpy and Russell machines agree remarkably well.

The drop tests were first plotted against the resilience, but it was at once evident that the strong irons were above the median and the flexible irons were below, so the results were plotted against the product of resilience and modulus of rupture with fair correlation, as shown in Fig. 22. In considering the nature of this test it seemed probable that the height of drop was governed largely by the elastic deflection rather than by the total deflection since in every case the bar is struck a series of blows approaching the breaking point, and several of these must produce pronounced "set," especially in the low strength, high deflection irons, such as iron X. The only approach that could be had was to correct the true total resilience by the same amount that the resilience changed on repeated loading to 80 per cent. This was accordingly done and the results plotted in Fig. 23. While no mathematical analysis was made of these two figures the results of Fig. 22 seem to be a little more consistent than those in Fig. 23, which leads us to believe that the real ultimate "set" is perhaps a closer function of the modulus of rupture than it is of the "set" at 80 per cent load. This is not unexpected for we have shown that both "set" and strength are generally related to the modulus of elasticity and, therefore, to each other.

CONCLUSIONS

1. The very small specimens, such as are used for steel, are not reliable indices of the impact strength of cast iron. Enger's modified Izod with a fairly large specimen is by far the best used, though there is no reason to believe the same size specimen would not give equally good, and perhaps better, results in a Charpy machine.

2. The Krupp-Stanton test gave relatively enormous differences in results for irons closely approaching each other in all other properties. It is difficult to see how this test means anything when applied to cast iron.

3. All notched specimens were unsatisfactory.

4. The tensile impact test does not seem to be a reliable index of impact value.

5. When using specimens 1.20 in. in diameter, the large pendulum machines of the Russell and Charpy type give results which follow closely the resilience measured in the transverse test.

6. The drop tests seem to indicate the impact resistance left in the bar after previous loading to a point just below the breaking point. A drop test, therefore, considered in the light of the transverse resilience would appear to be a useful index of the relative amounts of plastic and elastic deflection.

7. The bending curve of the transverse test, if the test is accurately carried out, is capable of giving most of the information needed about cast iron, and the Brinell hardness determined over the whole cross-section is the most valuable supplementary test.

8. The drop-test machines differ greatly in their construction. They would probably become quite generally used if the machines were carefully standardized in all dimensions. The tests would then give valuable corroboration to the results of the transverse tests.

9. The committee does not recommend at this time any move toward an impact requirement in specifications.

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Buffalo Foundry and Machine Co.,
Cadillac Motor Car Co.,
Crane Co.,
Deere and Co.,
Frank Foundries Corp.,
General Electric Co.,
Gray Iron Inst.,
Griffin Wheel Co.,
Hunt-Spiller Manufacturing Co.,
Ingersoll-Rand Co.,
International Nickel Co.,
Lynchburg Foundry Co.,
New York Air Brake Co.,
Otis Elevator Co.,
Pittsburgh Electric Furnace Corp.,
Standard Foundry Co.,
Southern Wheel Co.,
Stockham Pipe and Fittings Co.,
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International Nickel Co.—for Charpy tests.

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University of Michigan, F. N. Menefee—for Izod tests.

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American Cast Iron Pipe Co. for analyses, transverse test, drop tests, hardness, "set" tests, all calculations, graphs, and the preparation of this report.

COMMENTS BY DISCUSSERS

The report on impact testing was sent out in preliminary form to those cooperating, and to a number of other interested metallurgists and engineers for comment. Since much of the discussion submitted was considered in the final revision of the report, and as most of it was in more or less informal communication to the chairman of the subcommittee, it is thought best to present this body of discussion in the form of abstracts, giving only the salient features of each discussion and omitting, to a great extent, the discussion which had no bearing on impact properties or their relation to other tests.

H. Jungbluth and P. A. Heller (Krupps, Essen, Germany) note that modulus of elasticity in tension and compression are given at the same proportion of the breaking strength. They consider that it is more useful to give them at the same stress and draw attention to the fact that, at the lower stresses the modulus changes very slowly with the compressive stress. They note the correspondence between the results of Meyersberg on the relation between "set" and the shape of the bending curve and those shown in the report. They consider the relation shown for Rockwell-Brinell hardness to be more suitable for cast iron than Petrenko's equation.

The great difficulty of finding a test for toughness of cast iron is shown by Fig. 18. The values for Charpy impact bear out the tests made in Germany. It is perhaps best to stick to the drop test.

Of special interest to them is Fig. 17. The quotient $\frac{R_T}{R_\Delta}$ is no more than a measure of the curvature of the bending curve. The modulus of elasticity as used considered total bending, not the elastic. The ratio of this modulus at half load to that at breaking is, of course, another expression of the same thing. This property is better expressed by the exponent in the Meyersberg (modified Bach) formula. More interesting, however, is the upper portion of the figure where is expressed an extraordinarily important property of cast iron, which has been very difficult to determine. This proportion of resilience after repeated loading in one direction to the resilience of a "fresh" bar is a measure of the performance under repeated, but not reversed, loading and means that the one that loses the most resilience is the poorest in such service.

They believe that this effort of the A.S.T.M. brings a new viewpoint and are convinced that the work of the committee furnishes a worthwhile insight into the properties of cast iron.

I. Sugimura (Tokyo, Japan) writes that too much stress was laid on the transverse test and that most of the irregularities in tests of cast iron are due to this test. He discusses the derivation of the bending formulas and shows that they are liable to gross errors when applied to cast iron. He believes the results would have been worth more if they had been compared to tensile properties.

J. E. Hurst (Chesterfield, England) writes that he has long held the view that the resilience is the most satisfactory expression of the toughness of cast iron. For an impact test it is only necessary to agree on a test easily made even though the values are empirical.

A. leThomas (Paris, France) notes that the modulus of elasticity has long been recognized by the French as a useful figure in cast iron testing. He objects to expressing breaking load of the transverse test as modulus of rupture as it is only a comparative figure.

J. B. Kommers (University of Wisconsin) points out the following useful average ratios between fatigue and six other properties:

	Tensile Strength	Modulus of Rupture, 0.5 by 5-in. Bar	Compressive Strength	Modulus of Rupture, 1.20 by 18-in. Bar	Shear Strength	Brinell Hardness Number	Russell Impact Energy
Average ratio of endurance limit to other properties	0.50	0.23	0.14	0.23	0.36	0.80	26
Mean variation from the average percentage	7.4	8.1	10.0	10.4	10.5	12.7	31.6
Maximum variation from the average percentage	26	25	29	58	25	35	211

"The table shows that the compressive strength, modulus of rupture, shear strength and Brinell hardness are fair measures of the endurance limit, but they are not as reliable and consistent as the tensile strength."

H. W. Gillett (Columbus, Ohio) comments on the Krupp-Stanton test as follows:

> "Since individual values vary so widely, plotting them against other properties can hardly be expected to plot smoothly. It is doubtful as to whether the test is of value, at a single height of fall, since for weak irons, the test approaches a single blow impact test and for strong irons, an endurance test. If one varied the height of fall and compared the height required to break in say 10,000 blows, the test would probably give a sounder differentiation, though this would, of course, be too time-consuming."

J. G. Pearce (Birmingham, England) writes as follows:

"The principal aim of the work appears to be to determine a suitable impact test. In this connection, if it is a necessary condition that the impact test should correlate with an existing mechanical test before confidence can be placed in it, it may be argued that the impact test is not necessary. If two tests correlate satisfactorily, one can be discarded. On the other hand, for tests which do not correlate, a good deal of trial and experience is necessary to establish a satisfactory empirical test. Impact tests range from the single blow of the Izod or Charpy type to the fatigue test of the Wöhler type. The early experience of the British Cast Iron Research Association with a single-blow test suggested that it was scarcely suitable for cast iron, especially when used on small bars. The energy absorbed is small and the results erratic and as a consequence this type of test was abandoned. Table III of the report shows that the range covered by the Izod and Charpy tests is very narrow, whether the bar is notched or unnotched. The fatigue test is unsuitable as a routine test and consequently we adopted the repeated-blow impact test. A relationship between the energy of the blow and the number of blows to fracture (not necessarily the same for different irons) has been shown.[1] It should be understood that this test is used wholly as an empirical test and no attempt is made to relate it to other tests. The results obtained cannot be used in design and it is emphatically not suitable as an acceptance test. Attempts to improve cast iron can scarcely do more than double or treble the tensile strength of average material. The range offered by the repeated impact test, however, is much wider. In a recent case, for example, of two irons of somewhat similar composition differing mainly in graphite size and distribution, the tensile strengths were, respectively, 30,400 and 64,300 lb. per sq. in. The corresponding transverse moduli on the 1.2-in. bar were 57,500 and 112,000 lb. per sq. in. The repeated impact test, however, gave 253 and 2886 blows to fracture, respectively. The test is used to discriminate between one iron and another on the principle that everything done to improve a cast iron with respect to reduction of total carbon, graphite size, phosphorus, alloy additions, etc., will improve the repeated impact test and figures up to over 100,000 blows have been obtained on austenitic irons, and five-figure results are not uncommon on special irons. A cylinder-type iron withstands about 800 blows and a modern high-quality iron 2000 to 3000. The best iron in the series now under consideration gives about 20,000. Table III of the report shows clearly the improvement effected by low carbon and small graphite, etc. On the whole, the test appears to have graded the series very satisfactorily, in integrating all the factors improving the fragility, subject to the reservation, of course, that they were not necessarily intended to be cast or used in the section employed and that a good deal of metal was removed in machining.

"With respect to the so-called 'wildness' of the results, it should be remembered that erratic variations are also experienced in the case of steel subjected to impact and that Charpy and Cornu-Thenard[2] demonstrated quite clearly that if proper precautions are taken to secure uniform and homogeneous material, the impact test gives results more regular even than the ordinary static tests.

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[1] J. G. Pearce, "The Correlation of Mechanical Tests for Cast Iron," *Transactions*, Am. Foundrymen's Assn., Vol. 38, p. 673 (1930).

[2] G. Charpy and A. Cornu-Thenard, "New Experiments on Shock Tests and on the Determination of Resilience," *Journal*, Iron and Steel Inst., Vol. 96, No. 2, p. 61 (1917).

There is, therefore, a high degree of probability that the variations disclosed by the impact test arise from the material itself and that to seek a test which obscures these variations may be to defeat the very object which we have in view. It is necessary, of course, to discriminate between the intrinsic impact properties of the metal itself and weakness due to unsoundness, internal stress, etc., which may arise from the founding operation. Also it is not suggested that the variations between one test bar and another on this test necessarily have practical importance in the present state of the art.

"The impact test is usually applied in the case of steels to detect an abnormal or brittle condition, usually arising from defective heat treatment. It is assumed that an impact test for cast iron is desired for the purpose of determining its resistance to shock in a normal condition. In the writer's opinion it is at present essentially a test for works and laboratory use rather than for specifications and acceptance tests and hence would not make any recommendation for a test for general use."

Mr. John Shaw (Southsea, England) makes the following comments:

"I am particularly interested in the subject of impact testing for cast iron because of a number of failures in actual work where an iron that had good transverse and tensile strength, together with a perfect pearlitic structure, failed badly under impact. The work which Mr. MacKenzie and his committee have done, while of great importance and embodying much useful information, throws little light on this side of the problem. If you abstract all of the plain cupola irons from Tables II, III and IV of the report and they form half, and arrange them in order of their transverse strength, as shown in Table VIII, they will illustrate the points I wish to discuss:

"An examination of this table reveals that about two-thirds of the compositions are such that no one would use them for highest strength castings averaging in thickness 1.2 in. or over. Irons W and C fall below the lowest allowable tensile strength in the Society's Specification A 48 – 32 T, while iron D for a well-known reason (high phosphorus) fails in transverse strength. An approximate analysis used on this side (England) for iron of this class would be total carbon 3.2 per cent, silicon 1.5 per cent. One can only think that quite a number of these irons were used for such castings as motor cylinders, etc., or that production in the machine shop was of far more importance than strength or resistance to wear. The great variation in the composition of the iron does, however, throw some light on several factors. Irons W and C with a combined carbon content of 0.80 and 0.86 per cent must have an almost entirely pearlitic structure, yet both fail in the tensile strength requirement, thus showing the dominant weakening power of graphite. Iron D was well worth including if only to show how futile it is to make the tension test the deciding factor in any national specifications. An inspecting engineer coming into a strange foundry and receiving castings from iron D would pass them on the tension test, yet the same iron would fail badly on either transverse or impact results. There is no doubt that the ease with which the tension test requirement can be met has greatly influenced some foundrymen in its favor.

"Table VIII shows how impossible it is to fix a given constant that will convert the result of one test into terms of either of the other two. The variation on the ratio between one and another on the results shown are 39.3, 30 and 55 per cent, as given in the last three columns. It is true that at a foundry under close control as regards both practice and materials an approximate constant can be obtained while these conditions remain.

"It is also apparent that, due to the 'damping' effect and also probably the sinking of the test bar into the steel supports after each blow, the softer the iron, the nearer does the ratio between the transverse and impact approach each other (see the last two columns of Table VIII).

TABLE VIII.—PROPERTIES OF VARIOUS IRONS.

	Chemical Composition, per cent				Modulus of Rupture, 1.20-in. Diameter Bar, lb. per sq. in. $\times 10^{-3}$	Tensile Strength, 0.505-in. Diameter Bar, lb. per sq. in. $\times 10^{-3}$	A.S.T.M. Specifications A 48 - 32 T		Impact, Drop Test No. 1, Average Drop, in.	Ratio, Modulus of Rupture to Tensile Strength	Ratio, Modulus of Rupture to Impact	Ratio Tensile Strength to Impact
	Total Carbon	Combined Carbon, by Difference	Silicon	Phosphorus			Modulus of Rupture, lb. per sq. in. $\times 10^{-3}$	Tensile Strength, lb. per sq. in. $\times 10^{-3}$				
Iron V......	2.50	1.00	2.20	0.04	92.0	47.23	60	40	13.2	1.95	7.0	3.58
Iron T......	3.49	1.33	0.53	0.33	75.2	34.95	50	35	12.6	2.15	6.0	2.77
Iron E......	3.12	0.68	2.18	0.63	73.2	32.50	40	30	11.2	2.25	6.5	2.90
Iron A......	3.49	0.77	1.68	0.74	65.1	29.47	35	30	10.5	2.21	6.2	2.80
Iron H......	3.39	0.64	2.50	0.43	63.9	31.50	35	30	9.2	2.02	6.83	3.42
Iron B......	3.53	0.84	1.67	0.68	62.2	28.50	35	25	9.2	2.19	6.76	3.4
Iron O......	3.43	0.68	2.35	0.20	58.7	25.02	30	25	9.5	2.34	6.20	3.1
Iron I.......	3.41	0.56	2.44	0.63	48.8	20.00	25	20	7.0	2.44	6.9	2.86
Iron F.......	3.61	0.68	2.06	0.75	49.2	22.42	25	20	7.5	2.20	6.6	3.00
Iron W......	3.79	0.80	1.47	0.12	47.0	18.27	20	Fail	8.2	2.57	5.73	2.23
Iron C......	3.95	0.86	1.90	0.07	37.7	18.32	20	Fail	7.0	2.05	5.4	2.62
Iron D......	3.25	0.59	2.08	1.99	33.3	21.28	Fail	20	4.3	1.56	7.7	5.00
						Variation, per cent............				39.3	30.0	55.0

TABLE IX.—PROPERTIES OF SOME IRON BARS.

All bars tested at 0.564-in. Diameter.

	Chemical Analysis, per cent							Tensile Strength, lb. per sq. in.			
	Total Carbon	Silicon	Manganese	Sulfur	Phosphorus	Nickel	Chromium	1-in. Diameter Bar	3-in. Diameter Bar	$5\frac{1}{2}$-in. Diameter Bar	
										Edge	Center
Bar C-6............	3.35	2.10	0.72	0.09	0.72	....	....	32 700	18 800	22 800	13 900
Bar D-4............	3.20	1.21	0.91	0.10	0.51	....	....	36 100	25 500	28 900	23 500
Bar J-15...........	3.16	2.01	0.94	0.09	0.47	0.95	....	35 600	29 100	29 300	24 900
Bar G-8............	3.22	0.98	0.87	0.12	0.56	1.64	....	49 500	35 400	36 500	33 200
Bar M-16...........	3.32	1.26	0.75	0.12	3.9	1.08	0.32	41 700	29 600	32 700	27 100

"This brings us to the actual method of impact testing. If we are to accept as a dictum (*1*) that the size of the test bar must bear some near relation to the average thickness of the casting it represents, and (*2*) that to take the inner core of a test specimen to test is no correct test of the full section, then the ordinary Izod, Charpy or Krupp-Stanton repeated impact tests are ruled out at once as being suitable for testing cast iron. Even the repeated increasing drop test as used by MacKenzie has only a limited scope.

"Let us deal with the second point first. It has usually been taken for granted that to turn a small test specimen from the center of a larger diameter bar was a true criterion of the strength of the large bar (see tables given in the Symposium on Cast Iron in the section on Effect of Section Size[1]). A glance at Table IX will show how absurd this is.

"If you take C-6, a bar 0.564 in. taken from the edge of the 5½-in. diameter bar registers 22,800 lb. per sq. in., while the one taken from the center of the same 5½-in. bar breaks at 13,900 lb. per sq. in., a difference of about 40 per cent in favor of the outer section. When it is remembered that the area of this outer section is at least four times the area of the inner core, it is seen how untrue is the figure of 13,900 lb. per sq. in. as representing the strength of the whole bar. While it may be taken for granted that of two bars, each cast of the best composition suitable for their respective diameters, the larger size diameter bar will be the weaker because of the softer inner core. But the difference will not be anything like the amount shown by the tension test. This point has been stressed because the designer, when required to reduce his scantlings as much as possible, is confronted with this supposed great drop in strength with increased thickness, and turns to some other material without any necessity.

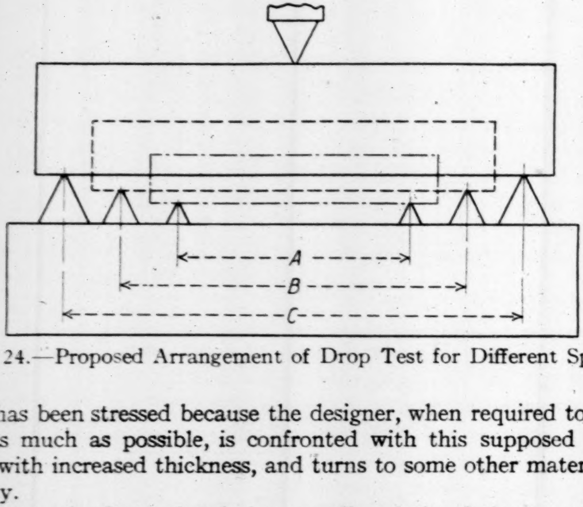

FIG. 24.—Proposed Arrangement of Drop Test for Different Spans.

"Coming to the first point, it is generally admitted that any test bar for cast iron to be at all representative should be cast in a section as near as practical to the casting represented. This has been recognized in Specifications A 48 – 32 T for Gray-Iron Castings[2] and you will find it equally necessary to conform to this rule in any form of impact test adopted. The writer has used the American Cast Iron Pipe Co. test for years but found the results of little guidance unless the structure of the bar was in line with that of the casting. For instance: with iron of total carbon 3.2 per cent, silicon 0.75 per cent, the 1¼-in. square bars cast from the ladle would be badly mottled or white and generally broke with the first drop of 6 in., while the bars machined 1¼-in. square from the 2½-in. down runner of the casting from the same metal would register about 20 or 27 drops of ½ in. increase each blow. How this question is to be met rests with the committee. The following suggestions made with some diffidence is the line I should take:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part II, p. 190.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol 32, Part I, p. 625 (1932); also 1932 Book of A. S. T. M. Tentative Standards, p. 179.

"If the American Cast Iron Pipe Co. type of drop test is decided upon and for the present the same size bars adopted as in Specifications A 48 - 32 T, but square instead of round (Fig. 24), then by increasing the size of the bottom heavy anvil so as to take three sets of hardened steel centers at different widths so as to take the different length and size of bars the outer steel centers, *C*, would be ¼ in. higher than the middle ones, *B*, while the centers *A* would be a further ¼ in. lower. The dimensions *A*, *B*, and *C*, would need to be calculated to give a relative figure for each size of bar.

"In a German roll foundry, a large Charpy type machine is used which takes bars 2¼ in. in diameter. This could be modified to take different size bars at variable spans so the test would yield comparative results for each size of bar."

Respectfully submitted on behalf of the subcommittee,

J. T. MACKENZIE,
Chairman.

APPENDIX

MICROSTRUCTURE OF IRONS IN IMPACT INVESTIGATION

By R. M. Allen[1]

This report outlines the results of microscopical examination made of the various irons studied for impact and other physical data.

One section, transverse to the test bar, was polished, etched and studied as to the nature and amount of graphite, nature of the pearlite (or other matrix), amount of free ferrite (or cementite) and amount of steadite. On account of the number of irons (25 in all) it was not deemed advisable to make a complete set of micrographs showing all the characteristics of the microstructure, but only a sufficient number to properly illustrate the series when supplemented by suitable descriptive matter

Graphite:

As the variation in the form and amount of graphite is the largest single factor, out of the 25 samples, 9 were chosen as representative of the entire lot and the nature of the graphite of the balance can be readily comprehended by reference to one of the 9 selected as representing the types of graphite structure. As a matter of fact, in many cases, entirely different graphite pictures could be obtained by a change of position on the section, especially as regards the distance from the center, although in others the structure is fairly uniform throughout. In order that the micrographs might be fairly representative as regards each other, a uniform distance of approximately ¼ in. from the outer edge was set for the area to be photographed. Likewise, in comparing the other samples not photographed with those types shown in the photomicrographs, it will be understood that similarly located areas are implied. Where much variation occurs from the area photographed, such will be noted in describing the individual irons. A uniform magnification of 100 diameters was employed for photographing the graphite.

The irons used as types for graphite structure are as follows:

Iron		Iron	
B	Fig. 1	J	Fig. 6
C	Fig. 2	K	Fig. 7
D	Fig. 3	Q	Fig. 8
F	Fig. 4	V	Fig. 9
H	Fig. 5		

Pearlite and Matrix:

Because of the size of the test bars, there is by no means the extreme variation in the nature of the pearlite that would result if the same irons were cast in very heavy sections, that is, the spread of difference would be much more noticeable in the latter case and it would be easier to differentiate between certain irons; nevertheless, the difference between irons is still sufficient so that by careful study they can be graded in a complete series of from 1 to 25 as to the particular characteristic under consideration, in its relation to impact strength.

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[1] Consulting Metallurgist, Bloomfield, N. J.

There are two microscopically visible conditions, as regard the nature of the pearlite, that can be taken into account. These are the fineness of the laminations (number of cementite plates per unit measurement) and the size of the pearlitic (or alpha iron) grains. The former, often, but not always, bears some relation to the amount of combined carbon but, other things being equal, the finer the lamination the higher the physical characteristics of the iron.

The pearlitic grain size corresponds identically with grain size in steel; consequently, it will be evident that in this case also, other things being equal, the finer the grain size the higher the physical characteristics of the iron. As far as the nature of the pearlite is concerned we can therefore have four limiting conditions, as follows, each of which will be related in some degree to the ultimate nature of the iron: (1) Fine pearlite, fine grain; (2) fine pearlite, coarse grain; (3) coarse pearlite, fine grain; (4) coarse pearlite, coarse grain. The variation between the coarsest and finest pearlite laminations found in any of the irons ranges from about $1\frac{1}{2}$ to $\frac{1}{4}$ micra spacing, a considerably more limited range than would be found in castings made from the same irons. It should be understood that there is a considerable variation in the pearlite in various areas of the same specimen, so that a general average must be ascertained by careful examination of the entire surface.

Table VII of the report,[1] the purpose of which, in relation to the impact values of the various irons, will be evident later, lists 23 of the irons giving the order of occurrence of each with respect to:

1. The graphite (by appearance),
2. Amount of steadite present,
3. Lamination fineness,
4. Grain size of the pearlite, and
5. The amount of ferrite.

The position of each with respect to the others was determined solely by visual examination (the personal equation naturally being a factor), the basis of judgment being the probable effect the characteristics under observation would have on the impact strength when compared with those above or below. The arrangement is such that No. 1 represents the poorest and No. 23 the best in order of occurrence.

It is not at all difficult to determine several of those at the ends of the series, but the problem of properly allocating those in the center is more difficult. As the arrangement of the series with respect to the amount of steadite present showed almost perfect accord (only about 4 samples being out of place) with the samples when listed as per the chemical analysis for phosphorus content, the latter was finally used instead, so that this column could also be headed, "Phosphorus Content."

Description of Microstructure of the Irons:

As the condition of the pearlite, free ferrite and steadite with respect to the irons as a whole is shown by Table VII of the report,[1] these will only be commented on in special cases.

Iron A.—Graphite, considerable in amount but not in large flakes, mostly short and stubby; dispersion quite uniform, similar to iron B (Fig. 1), but if anything, more stubby.

Iron B.—Graphite, considerable in amount, flakes fairly short, but frequently with longer and thinner ones interspersed. Dispersion fairly uniform. Average condition shown in Fig. 1.

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[1] See p. 106.

Iron C.—Graphite very excessive with fairly uniform dispersion. Some flakes very long. Average condition shown in Fig. 2.

Iron D.—Graphite of two varieties, large coarse masses, apparently representing several flakes which have coalesced, and fine flakes, not abundant or excessively long. Dispersion otherwise fairly uniform. Figure 3 shows average condition. This iron shows the maximum amount of steadite, an obviously undesirable condition as regards impact strength. Figure 3, although unetched, shows evidence of the phosphorus segregation (steadite) around the dendrites, but the general appearance of this constituent is better shown in Fig. 10 at 200 diameters (etched).

Iron E.—This iron has fine graphite on the outside of the section, much coarser in the center, while in the intermediate zone the flakes are short and relatively fine. In the area ¼ in. from the outer edge they are similar to those shown in Fig. 6.

Iron F.—Graphite is extremely variable, even in the intermediate zone, ranging from coarse to extremely fine. The dispersion is variable, areas of both coarse and fine being segregated in spots. Figure 4 shows the typical appearance of this sample, the photograph being taken on a border line between coarse and fine areas, so that both are evident.

Iron G.—Graphite in occasional clusters of heavy radiated flakes, interspersed in areas of fine flakes. Mostly like iron F (Fig. 4). Dispersion quite mixed throughout entire area of test bar.

Iron H.—Graphite abundant but very finely divided. Not much evidence of primary flakes, but much secondary. Fairly uniform dispersion. Figure 5 shows typical appearance.

Iron I.—Some coarse graphite, almost nodular, interspersed with flakes extremely fine and attenuated. Flakes considerably coarser at center of test bar. In general as per Fig. 7, iron K. As this iron is among those with coarse pearlite and also had the most free ferrite of any of the irons, Fig. 11 (× 2000) was taken to illustrate this iron for purposes of comparison of these features with those near the other end of the list.

Iron J.—Uniformly fine primary graphite, moderate in amount, with secondary flakes of extreme fineness. Dispersion of coarse and fine flakes uniform. Appearance shown in Fig. 6.

The pearlite in both lamination fineness and grain size, also the absence of free ferrite and steadite, put this sample among the best of the lot. Figure 12 (× 2000) gives a good idea of the appearance of this iron at high magnification.

Iron K.—Some large scattered graphite masses, but mostly in extremely thin elongated flakes, very evenly dispersed. Figure 7 shows the typical appearance.

Iron L.—Graphite mostly in fine attenuated flakes with occasionally larger, short stubby masses, quite similar to iron K (Fig. 7). Dispersion uniform.

Iron M.—Graphite in general similar to iron K (Fig. 7) except for a small area in the center of the bar where coarser flakes predominate.

Iron N.—Graphite flakes rather sparse, short, stubby and in general well isolated, some fine secondary groups. This iron was uniformly martensitic from the center to outside of bar, as regards the dendritic axes, with the matrix surrounding the dendrites (the last metal to solidify) still in the austenitic state. Within the austenite is considerable eutectic similar in appearance to steadite, but evidently a copper alloy, probably not in a final state of equilibrium. Figure 13 (× 100) shows the low-power appearance of this iron. The graphite is easily recognized, although the iron was etched. The dark areas are martensitic, while the white areas show the austenite, within which can be seen the phosphorus containing areas. Figure 14 (× 750) shows the martensite in more detail.

Iron O.—Graphite of two types, coarse stubby flakes with thin attenuated flakes interspersed, mostly like iron K (Fig. 7). The dispersion is fairly uniform, with larger flakes occupying a small area in the center of the bar.

Iron P.—Not submitted for examination.

Iron Q.—Graphite mostly in extremely short and delicate flakes, well separated and not numerous. Dispersion uniform and general appearance as shown in Fig. 8. This iron showed considerable steadite and also quite a little free ferrite. The pearlite also was quite variable, ranging from fairly coarse to areas entirely sorbitic. Figure 15 (× 2000) shows in one field coarse pearlite and sorbite, free ferrite, and steadite. From the extremely broken up condition of the matrix, it is apparent that this iron is properly ranked as of finest pearlitic grain size.

Iron R.—At the surface of the bar the graphite is very fine, gradually increasing in size toward the center. The flakes are of two kinds—large, stubby, and secondary thin, delicate flakes, mostly like iron K (Fig. 7) but more noticeably patterned around the dendrites.

Iron S.—Graphite in somewhat segregated areas of coarse stubby flakes and extremely fine secondary flakes, the latter largely in forced arrangement around the dendrites. Except for reduced quantity and more evident dendritic positioning, similar to iron F (Fig. 4).

Iron T.—Graphite quite fine at surface but increasingly coarse toward center. Flakes mostly of the thin, stubby variety, appearing in the intermediate zone similar to iron Q (Fig. 8).

Iron U.—Graphite abundant, the flakes long, thick and sinuous, similar in appearance to iron C (Fig. 2). Dispersion fairly uniform throughout the bar.

Iron V.—Graphite scarce, in very fine flakes and extremely subdivided secondary graphite, but practically all of it forced into positions surrounding the dendrites. The dispersion is uniform throughout the bar, the appearance in almost any area being as shown in Fig. 9. This arrangement of graphite is not conducive to maximum physical values, especially resistance to impact.

Iron W.—Graphite abundant, occurring in two forms, stubby and nodular masses, and very fine attenuated flakes, similar in general to iron K (Fig. 7) except for increased quantity. Dispersion fairly uniform, flakes somewhat coarser in center of bar.

Iron X.—Graphite flakes vary much in size from occasional rather coarse to many that are extremely fine; increasingly coarser from outside to center of bar. In general, corresponding in appearance to iron H (Fig. 5).

The matrix of this iron was entirely austenitic with an interstitial eutectic (copper controlled), formed as the final solidifying material.

Iron Y.—Graphite uniformly fine and very little flakiness, with no clustering. Dispersion uniform. In general similar to iron J (Fig. 6). Pearlite very finely laminated, merging into sorbite. Steadite in small patches common.

Iron Z.—Graphite flakes fairly long, but extremely thin and uniformly dispersed. Similar to iron Q (Fig. 8). A pearlitic iron, the pearlite quite variable, from medium coarse to almost sorbitic, occasional evidence of ferrite; steadite almost nil.

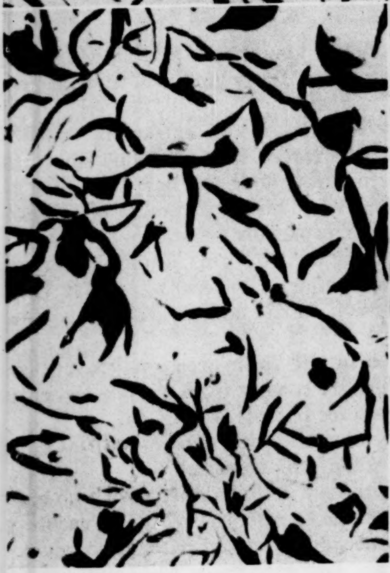


FIG. 1.—Iron B, Graphite (× 100).

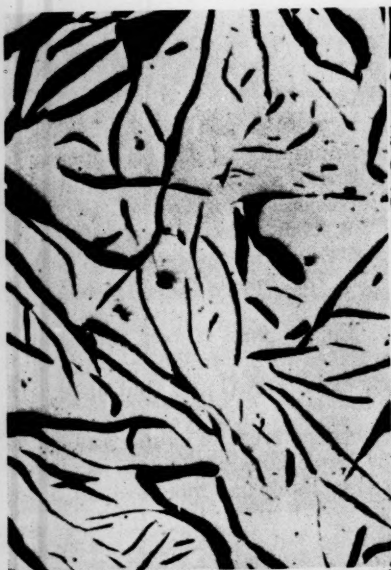


FIG. 2.—Iron C, Graphite (× 100).

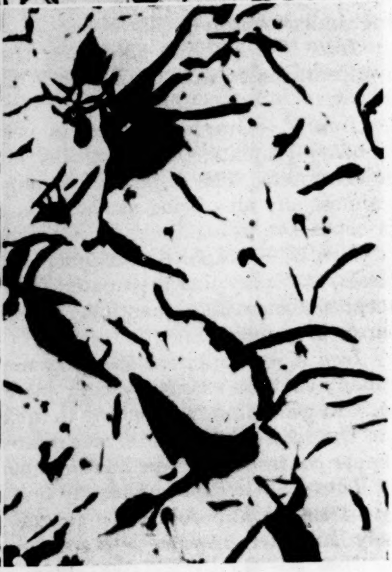


FIG. 3.—Iron D, Graphite (× 100).

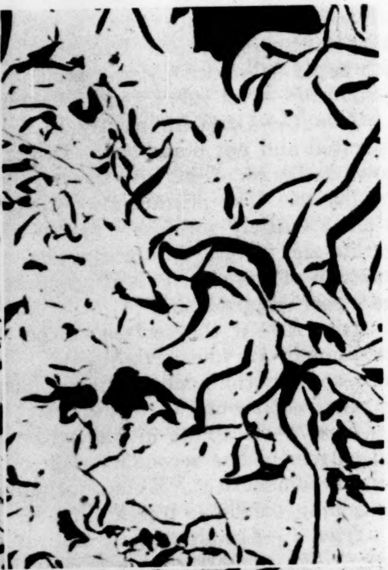


FIG. 4.—Iron F, Graphite (× 100).

FIG. 5.—Iron H, Graphite (× 100).

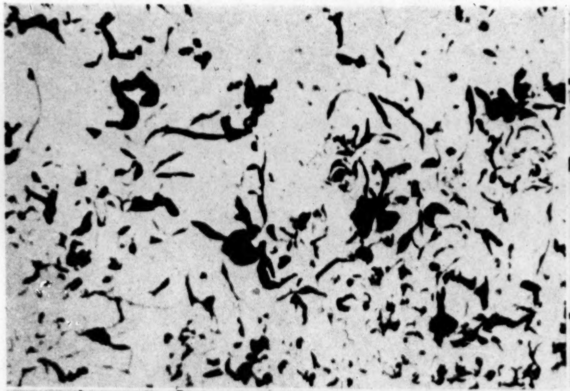
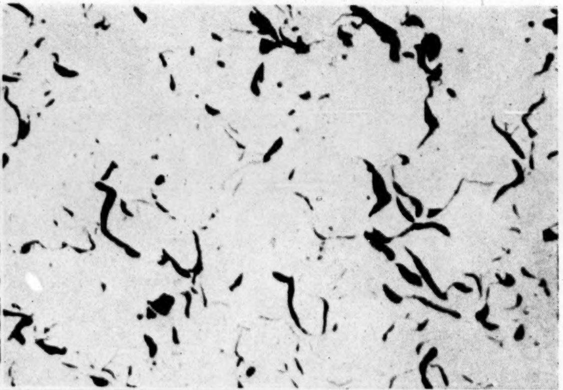


FIG. 6.—Iron J, Graphite (× 100).



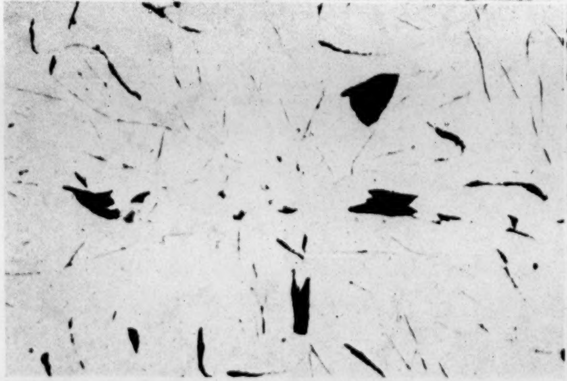


FIG. 7.—Iron K, Graphite (× 100).

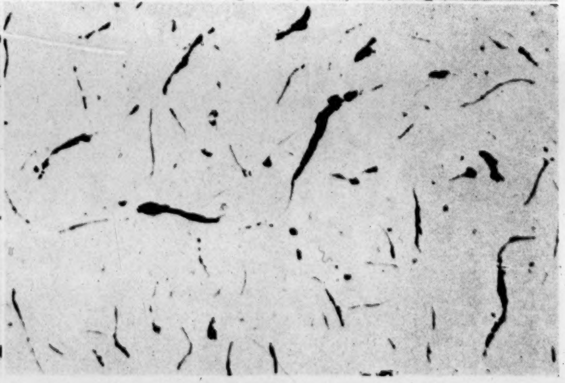


FIG. 8.—Iron Q, Graphite (× 100).

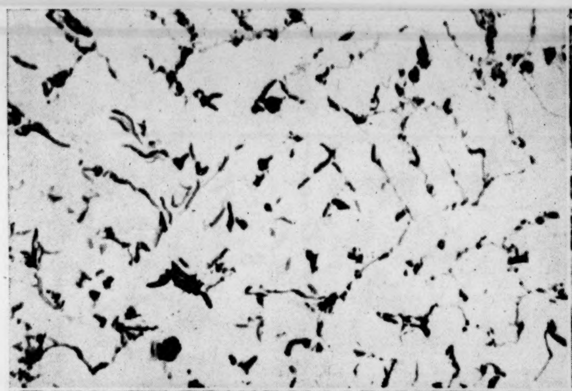


FIG. 9.—Iron V, Graphite (× 100).

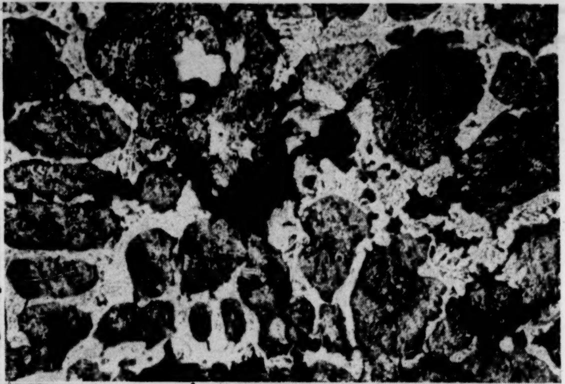


FIG. 10.—Iron D, Showing the Excessive Amount of Steadite, Etched (× 200).

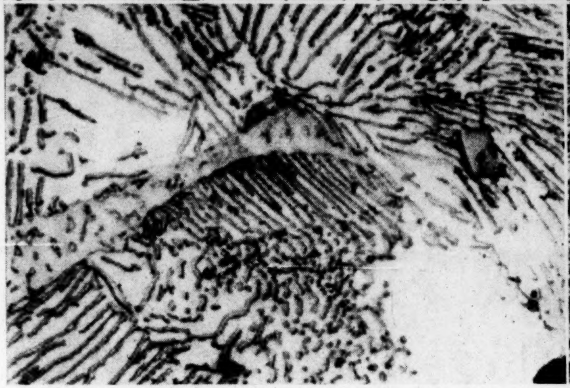


FIG. 11.—Iron I, Showing the Coarse Pearlite and Considerable Ferrite (× 2000).

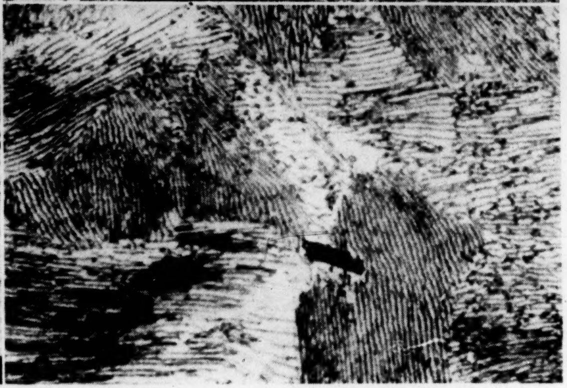


FIG. 12.—Iron J, Showing Fine Grain Size and Fine Laminations of the Pearlite (× 2000).

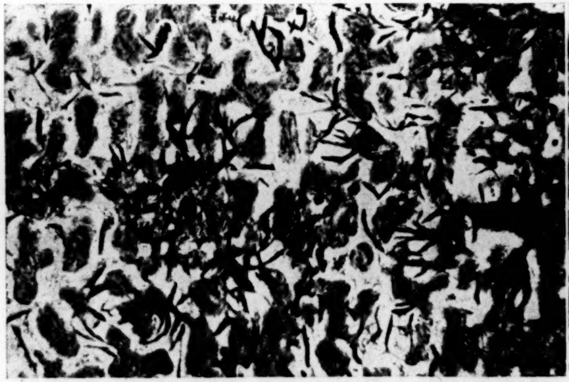


FIG. 13.—Iron N, Showing Graphite, Martensitic Matrix With Interstitial Austenite and Phosphorus Controlled Eutectic (× 100).

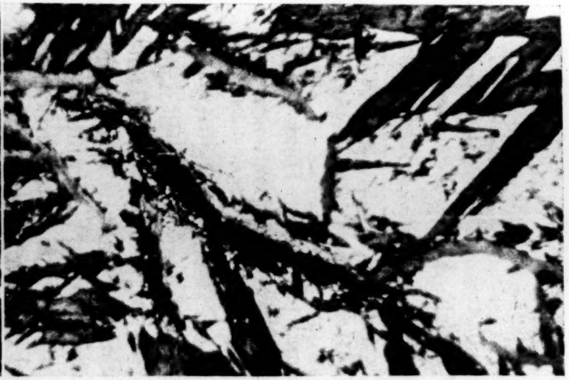


FIG. 14.—Iron N, Structure of Martensitic Matrix (× 750).

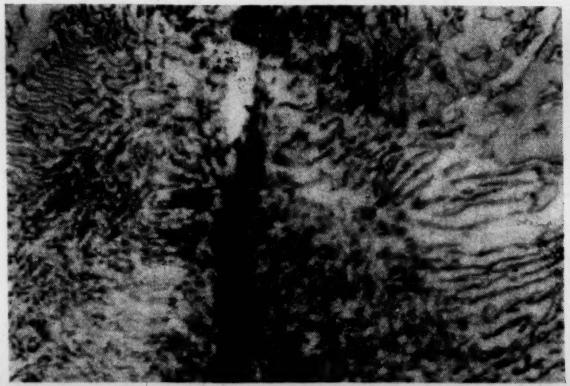


FIG. 15.—Iron Q, Showing Graphite, Pearlite, Sorbite, Ferrite and Steadite in One Field (× 2000).

REPORT OF COMMITTEE A-4

ON

HEAT TREATMENT OF IRON AND STEEL

During the past year the work of Committee A-4 on Heat Treatment of Iron and Steel has been transacted by correspondence and no meetings have been held.

The attention of the committee has been devoted solely to the proposed revisions of the terms "heat treatment," "annealing," "normalizing" and "tempering," appearing in the Standard Definitions of Terms Relating to Heat Treatment Operations (Especially as Related to Ferrous Alloys) (A 119 – 30)[1] and to a definition for the term "nitriding," which were recommended for publication as tentative revisions last year. The revised definitions are as follows:

Heat Treatment.—An operation or combination of operations involving the heating and cooling of a metal or an alloy in the solid state for the purpose of obtaining certain desirable conditions or properties.

NOTE.—Heating and cooling for the sole purpose of mechanical working are excluded from the meaning of this definition.

Annealing.—The operation of heating and cooling a material in the solid state—usually implies a relatively slow cooling.

NOTE.—Annealing is a comprehensive term. The purpose of such a heat treatment may be:

(*a*) To remove stresses
(*b*) To induce softness
(*c*) To alter ductility, toughness, electrical, magnetic or other physical properties
(*d*) To refine the crystalline structure
(*e*) To remove gases

In annealing, the temperature of the operation and the rate of cooling depend upon the material being heat treated and the *purpose* of the treatment.

Normalizing.—Heating iron-base alloys to approximately 100 F. above the critical temperature range followed by cooling to below that range in still air at ordinary temperature.

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[1] 1930 Book of A.S.T.M. Standards, Part I, p 426.

NOTE.—Normalizing is rarely practiced with hypereutectoid steels because of the coarsening of the grain and the tendency to crystallize cementite at grain boundaries or in needles. However, it may sometimes be necessary to normalize these steels by heating them above the Ac_{cm} line of the iron-carbon diagram as shown in Fig. 2.

Tempering (*also termed Drawing*).—Reheating iron-base alloys after hardening to some temperature below the critical temperature range followed by any desired rate of cooling.

Nitriding.—Adding nitrogen to iron-base alloys by heating the metal in contact with ammonia gas or other suitable nitrogenous material.

NOTE.—Nitriding is conducted at a temperature below the iron-carbon critical temperature range and produces surface hardening of the metal without quenching.

These revisions have been approved by the Joint Committee on Definitions of Terms Relating to Heat Treatment consisting of three representatives of the American Society for Steel Treating, three representatives of the Society of Automotive Engineers and three representatives of the American Society for Testing Materials. The committee recommends that the revised definitions of the above terms be advanced to standard. This recommendation has been submitted to letter ballot of the committee which consists of 41 members; 37 members returned their ballots all of whom have voted affirmatively.

This report has been submitted to letter ballot of the committee which consists of 41 members; 37 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

J. H. HALL,
Vice-Chairman and Secretary.

EDITORIAL NOTE

The tentative revisions of the terms heat treatment, annealing, normalizing and tempering appearing in the Standard Definitions of Terms Relating to Heat Treatment Operations (Especially as Related to Ferrous Alloys) and a definition of the term nitriding were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1933. The definitions in their revised form appear in the 1933 Book of A.S.T.M. Standards, Part I, page 425.

REPORT OF COMMITTEE A-5
ON
CORROSION OF IRON AND STEEL

Committee A-5 on Corrosion of Iron and Steel held two meetings during the past year. All of its work has shown substantial progress.

RECOMMENDATIONS AFFECTING STANDARDS

I. *Proposed Revision of Standard.*—The committee recommends that the Standard Methods of Determining Weight of Coating on Zinc-Coated Articles (A 90 – 30)[1] be revised as proposed by Subcommittee VII and continued as standard. The methods in their revised form are appended hereto. The committee accordingly asks for the necessary nine-tenths vote at the annual meeting in order that the revision in this standard may be submitted to letter ballot of the Society.

II. *Advancement of Tentative Standards to Standard.*—The committee recommends that the following four tentative specifications, proposed last year as tentative revisions of the corresponding existing standard specifications, be advanced to standard to supersede the present standards:

Tentative Specifications for Zinc-Coated (Galvanized) Iron or Steel Telephone and Telegraph Line Wire (A 111 – 32 T)[2] without revision;

Tentative Specifications for Zinc-Coated (Galvanized) Iron or Steel Tie Wires (A 112 – 32 T),[2] without revision;

Tentative Specifications for Zinc-Coated (Galvanized) Iron or Steel Wire Strand (Cable) (A 122 – 32 T),[2] without revision;

Tentative Specifications for Zinc-Coated Iron or Steel Chain-Link Fence Fabric Galvanized After Weaving (A 117 – 32 T),[2] revised by the addition of the following Note after Section 10 of the specifications:

NOTE.—*Adherence of Coating.*—No bend or mandrel test is specified for adherence of the zinc coating on chain-link fence fabric, galvanized after weaving, in the interest of facilitating the manufacture of fabric carrying an adequately heavy coating. The service to which this fabric is put does not require bending it to a degree which justifies the use of a bend or mandrel test to evaluate serviceability of the product.

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 385.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, pp. 589, 595, 609, 603 (1932); also 1932 Book of A.S.T.M. Tentative Standards, pp. 136, 142, 156, 150.

ACTIVITIES OF SUBCOMMITTEES

Subcommittee III on Inspection of the Annapolis Tests (J. H. Gibboney, chairman).—The sheets in this test[1] were inspected by representatives of the committee on October 31, 1932, and April 3, 1933. Five new failures, sheets D 8, 9 and 14 (No. 22 gage low-copper pure iron, Series A) and sheets X 6 and 8 (No. 22 gage low-copper pure iron, Series B, manufactured by the Inland Steel Co.) were found at the October, 1932, inspection. Seven new failures, sheets A 2 and 3 (No. 22 gage bessemer steel, Series A), sheets C 1 and 2 (No. 22 gage copper-bearing pure iron, Series A), sheet U 1 (No. 22 gage copper-bearing pure iron, Series B, manufactured by the Allegheny Steel Co.), and sheets X 2 and 3 (No. 22 gage low-copper pure iron, Series B, manufactured by the Inland Steel Co.), were found at the April, 1933, inspection. All failures were due to perforation and fringing along the bottom of the sheets.

Subcommittee V on Total Immersion Tests (F. B. Olcott, chairman).—The report of this subcommittee appended hereto shows progressive information on the sea water immersion tests on copper-bearing and non-copper-bearing metals at Key West, Fla., and Portsmouth, N. H., and on riveted ship plates and tubing at Portsmouth, N. H., and Port Arthur, Tex. While important developments are taking place the tests are not sufficiently advanced to warrant conclusions.

Subcommittee VI on Specifications for Metallic-Coated Products (F. F. Farnsworth, chairman).—Subcommittee VI in its report appended hereto, and as mentioned earlier in this report, is recommending that the tentative revision of four standard specifications for galvanized wire and wire products, proposed last year in the form of separate tentative specifications, be advanced to standard to supersede the present standard specifications. The revised specifications have been favorably received by all interested groups and when adopted will be submitted to the American Standards Association for consideration as American Standards. Comments from many sources have been received that the present grades of farm-fence and barb wire are not satisfactory and these specifications will receive careful study during the year.

Subcommittee VII on Methods of Testing (E. S. Taylerson, chairman).—This subcommittee is reporting with unanimous approval a revision of the Standard Methods of Determining Weight of Coating on Zinc-Coated Articles (A 90 - 30). The methods in their revised form as appended hereto[1] are recommended for immediate adoption as standard to supersede the present standard methods. The revision has been under consideration for several years, does not involve controversial matter and is based on present standard practice. The research group has under consideration further experimental results from one of the cooperating laboratories on the subject of industrial atmospheric tests. The Preece test group has developed additional information which will be considered in possible revision and interpretation of this test during the coming year.

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[1] For detailed tabulation of failures in the Annapolis tests up to 1930 see Report of Committee A-5, *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 221 (1930). For additional failures reported n 1931 and 1932 see *Proceedings*, Vol. 31, Part I, p. 171 (1931); Vol. 32, Part I, p. 100 (1932),

Subcommittee VIII on Field Tests of Metallic Coatings (R. F. Passano, chairman).—This subcommittee has continued its investigations on galvanized sheets, and presents in its report appended hereto extensive tabulations and graphs confirming previous findings, namely, that the relative resistance of zinc and iron to corrosion changes with location, and that at the two locations where the coatings have failed the durability of the zinc coating is substantially proportional to the weight of the coating. The results of inspections on specimens of coated hardware, structural shapes, tubular goods, etc., made at the five test locations at intervals during the past two years are given in a series of tables. The discussion of the various factors bearing on these tests and the statement summarizing the facts developed as the result of four years' exposure should have careful consideration before the information is used to select coatings for resistance to outdoor corrosion. The results of inspections at the end of the first year on electroplated coatings furnished with nickel and chromium are summarized, and tentative conclusions are given concerning factors bearing on the protective value of such coatings. The subcommittee contemplates starting the field tests on zinc-coated wire to develop data in support of specifications for wire and wire products.

Subcommittee IX on Metal Culvert Tests (H. E. Smith, chairman).—This subcommittee has been inactive during the year due to the prevailing period of business depression which delays the necessary support for a test of such magnitude as contemplated in the tentative program. This investigation will be revived as soon as conditions warrant.

Subcommittee X on Embrittlement Investigation (V. F. Hammel, chairman).—In the report of this subcommittee appended hereto progress is shown in completing this work. A small group is collecting information on the freedom of the intermediate size shapes to injurious embrittlement, on the susceptibility to serious embrittlement of open-hearth steel other than structural steel for bridges (A.S.T.M. Standard Specifications A 7 – 29), on the necessity of reducing the gage length for testing intermediate shapes with small holes, and on the necessity of measuring reduction in thickness in testing angles. Another group is seeking information concerning known cases of embrittlement in formulating a procedure and tests for detecting injurious embrittlement of cold-worked steel plates, bars, and other products commonly called hardware.

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[1] The revised methods were adopted as standard and appear in the 1933 Book of A.S.T.M. Standards, Part I, p. 317.—Ed.

The recommendations appearing in this report have been submitted to letter ballot of the committee with the following results:

Items	Affirmative	Negative	Not Voting
I. Proposed Revision of Standard			
Methods of Determining Weight of Coating on Zinc-Coated Articles (A 90 – 30), immediate adoption..........	64	0	9
II. Advancement of Tentative Standards to Standard			
Specifications for Zinc-Coated (Galvanized) Iron or Steel Telephone and Telegraph Line Wire (A 111 – 32 T)..........	53	0	20
Specifications for Zinc-Coated (Galvanized) Iron or Steel Tie Wires (A 112 – 32 T).....	53	0	19
Specifications for Zinc-Coated (Galvanized) Iron or Steel Wire Strand (Cable) (A 122 – 32 T)..........	56	0	16
Specifications for Zinc-Coated Iron or Steel Chain-Link Fence Fabric Galvanized After Weaving (A 117 – 32 T), as revised..........	52	0	21

This report has been submitted to letter ballot of the committee, which consists of 119 members; 73 members returned their ballots, of whom 63 have voted affirmatively and 2 negatively.

Respectfully submitted on behalf of the committee,

J. H. Gibboney,
Chairman.

James Aston,
Secretary.

Editorial Note

The revisions proposed for immediate adoption in the Standard Methods of Determining Weight of Coating on Zinc-Coated Articles were unanimously approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1933. The methods in their revised form appear in the 1933 Book of A.S.T.M. Standards, Part I, p. 317.

The Tentative Specifications for Zinc-Coated (Galvanized) Iron or Steel Telephone and Telegraph Line Wire; for Zinc-Coated (Galvanized) Iron or Steel Tie Wires; for Zinc-Coated (Galvanized) Iron or Steel Wire Strand (Cable), without revision; and for Zinc-Coated Iron or Steel Chain-Link Fence Fabric Galvanized After Weaving, as revised, were approved at the annual meeting and subsequently adopted as standard, to supersede the present standard specifications, by letter ballot of the Society on September 1, 1933, and appear in the 1933 Book of A.S.T.M. Standards, Part I, pp. 287, 293, 297, 281.

Sea Water Immersion Tests:

No. 22 Gage Sheets.—The test on No. 22 gage sheets exposed March 1, 1927, in sea water at the U. S. Naval Station, Key West, Fla., was completed August 12, 1932, all sheets having failed at that date. This test included 87 copper-bearing and 63 non-copper-bearing sheets and extended over a period of 1990 days (5.4 years). A detailed record of the failures is given in Table I (Plate I).

The No. 22 gage sheets exposed March 7, 1927, in sea water at the U. S. Navy Yard, Portsmouth, N. H., have all failed, the test being completed June 5, 1931. This test extended over a period of 1550 days (4.2 years) and included 86 copper-bearing sheets and 64 non-copper-bearing sheets. The detailed record of failures is given in the 1932 Report.[1]

No. 16 Gage Sheets.—The No. 16 gage sheets at Key West, Fla., exposed since March 1, 1927, have been given the routine monthly inspections. A total of 35 failures out of 138 sheets exposed have now been observed, the following 13 failures having occurred since the 22 failures recorded in the 1932 report:[2]

March 14, 1932.—Specimens II-1 (copper-bearing bessemer steel) Series A; CC-12 (low-copper pure iron) Series A.

July 13, 1932.—Specimen KK-6 (copper-bearing, acid open-hearth steel) Series A.

August 12, 1932.—Specimens ZZ-205 (copper-bearing bessemer steel, Youngstown Sheet and Tube Co.) Series B; ZZ-419 (non-copper-bearing open-hearth steel, Youngstown Sheet and Tube Co.) Series B.

September 14, 1932.—Specimen ZZ-418 (non-copper-bearing open-hearth steel, Youngstown Sheet and Tube Co.) Series B.

November 14, 1932.—Specimens ZZ-204 (copper-bearing bessemer steel, Youngstown Sheet and Tube Co.) Series B; BB-9 (non-copper-bearing open-hearth steel) Series A; CCC-18 (copper-bearing pure iron) Series A.

January 11, 1933.—Specimens ZZ-2 (non-copper-bearing bessemer steel, Youngstown Sheet and Tube Co.) Series B; ZZ-201 (copper-bearing bessemer steel, Youngstown Sheet and Tube Co.) Series B; OO-6 (low-copper open-hearth steel) Series A; YY-6 (low-copper wrought iron, Youngstown Sheet and Tube Co.) Series B.

The No. 16 gage sheet specimens exposed at Portsmouth, N. H., March 7, 1927, have been given the routine monthly inspections. A total of 30 failures out of 138 sheets exposed have now been ob-

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[1] See Report of Subcommittee V on Total Immersion Tests, Table II (Plate II); *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 105 (1932).

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 106 (1932).

Table I.—Report on Total Immersion Tests. Sheets Exposed Marc

No. 22 Gage S

Group	Designation	Series	Description	Average Analysis, per cent						Number of Sheets in Test												
				Carbon	Manganese	Phosphorus	Sulfur	Silicon	Copper		Mar. 16, 1928, 381 Days	Apr. 30, 1928, 427 Days	June 4, 1928, 462 Days	July 5, 1928, 493 Days	Sept. 7, 1928, 557 Days	Oct. 8, 1928, 588 Days	Nov. 7, 1928, 618 Days	Dec. 6, 1928, 647 Days	Jan. 7, 1929, 679 Days	Jan. 21, 1929,[a] 693 Days	Mar. 7, 1929, 738 Days	
A	Bessemer Steel	A	Non-Copper-Bearing	0.038	0.380	0.090	0.036		0.017	6		5					2					
Z	Bessemer Steel, Youngstown Sheet and Tube Co	B	“ “ “	0.062	0.405	0.100	0.043		0.014	6			1			2			1	1		
Z1	Bessemer Steel, Youngstown Sheet and Tube Co	B	“ “ “	0.075	0.448	0.092	0.035		0.140	6			102		101			101		101, 102, 108		
I	Copper-Bearing Bessemer Steel	A	Copper-Bearing	0.041	0.372	0.094	0.067	0.010	0.254	6			6, 21, 23						30			
Z2	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	“ “	0.058	0.370	0.093	0.043		0.266	6										204		202,
Z3	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	“ “	0.055	0.380	0.111	0.044		0.522	6										301		
B	Open-Hearth Steel	A	Non-Copper-Bearing	0.023	0.229	0.012	0.052	0.004	0.117	3										15		
F	Open-Hearth Steel	A	“ “ “	0.293	0.503	0.026	0.039	0.010	0.038	6			10						10			
O	Low-Copper Open-Hearth Steel	A	“ “ “	0.118	0.522	0.009	0.029	0.223	0.021	6	15, 17		16							9, 28		
Z4	Open-Hearth Steel, Youngstown Sheet and Tube Co	B	“ “ “	0.042	0.318	0.063	0.042		0.019	6	418		417, 418, 421									
B	Open-Hearth Steel	A	Copper-Bearing	0.038	0.232	0.009	0.063	0.004	0.167	3												
G	Open-Hearth Steel	A	“ “	0.290	0.510	0.027	0.039	0.010	0.241	6				10								
H	Copper-Bearing Basic Open-Hearth Steel	A	“ “	0.076	0.371	0.011	0.028	0.002	0.246	6			11							8		
M	Open-Hearth Steel, Alan Wood Steel Co	B	“ “	0.097	0.396	0.014	0.043	0.012	0.184	6					9							
T	Copper-Bearing Steel, Newport Rolling Mill Co	B	“ “	0.078	0.322	0.010	0.020		0.237	6			2									
Z5	Copper-Bearing Open-Hearth Steel, Youngstown Sheet and Tube Co.	B	“ “	0.067	0.351	0.045	0.052		0.187	6										501		
Z6	Copper-Bearing Open-Hearth Steel, Youngstown Sheet and Tube Co.	B	“ “	0.062	0.388	0.054	0.053		0.275	6			604									
D	Low-Copper Pure Iron	A	Non-Copper-Bearing	0.012	0.027	0.003	0.022	0.002	0.021	6											13	
S	Low-Copper Pure Iron, American Rolling Mill Co	B	“ “ “	0.009	0.016	0.007	0.020	0.008	0.022	6												
X	Low-Copper Pure Iron, Inland Steel Co	B	“ “ “	0.010	0.065	0.007	0.026		0.033	6	3						1					
C	Copper-Bearing Pure Iron	A	Copper-Bearing	0.025	0.034	0.006	0.039	0.020	0.198	6										12		
U	Copper-Bearing Pure Iron, Allegheny Steel Co	B	“ “	0.016	0.075	0.009	0.034	0.003	0.269	6												
V	Copper-Bearing Pure Iron, Whitaker-Glessner Co	B	“ “	0.012	0.048	0.008	0.020		0.299	6							6					
K	Copper-Bearing Acid Open-Hearth Steel	A	Copper-Bearing	0.112	0.438	0.090	0.044	0.002	0.231	6	3	6								27		
E	Puddled Iron	A	Copper-Bearing	0.039	0.032	0.114	0.021	0.110	0.241	6							4					
Y	Low-Copper Wrought Iron, Youngstown Sheet and Tube Co	B	Non-Copper-Bearing	0.030	0.052	0.146	0.021	0.213	0.019	6	5		3		1			4		2		
										150	6	2	14	1	3	1	4	2	3	14	1	
	Total Failures to Date										6	8	22	23	26	27	31	33	36	50	51	

[a] All specimens in the inspection on these dates were sand blasted to facilitate inspection

PLATE I.
PROCEEDINGS, AM. SOC. TESTING MATS.
VOL. 33, PART I.
REPORT OF COMMITTEE A-5:
TOTAL IMMERSION TESTS

MARCH 1, 1927, IN SEA WATER AT U. S. NAVAL STATION, KEY WEST, FLA.

GAGE SHEETS

Failures on Date of Inspections																																		
738 Days	June 6, 1929, 829 Days	July 3, 1929, 856 Days	Aug. 7, 1929, 891 Days	Sept. 6, 1929, 921 Days	Oct. 7, 1929,[a] 952 Days	Nov. 7, 1929, 983 Days	Dec. 6, 1929, 1012 Days	Jan. 7, 1930, 1044 Days	Feb. 10, 1930, 1078 Days	Mar. 7, 1930, 1103 Days	Apr. 7, 1930, 1134 Days	May 7, 1930, 1164 Days	June 6, 1930, 1194 Days	July 7, 1930, 1225 Days	Aug. 7, 1930, 1256 Days	Sept. 6, 1930, 1286 Days	Oct. 7, 1930, 1317 Days	Nov. 8, 1930, 1349 Days	Dec. 8, 1930, 1379 Days	Jan. 8, 1931,[a] 1410 Days	Mar. 10, 1931, 1471 Days	Apr. 10, 1931, 1502 Days	May 11, 1931, 1533 Days	June 11, 1931, 1564 Days	July 13, 1931, 1596 Days	Aug. 13, 1931, 1627 Days	Sept. 12, 1931, 1657 Days	Nov. 14, 1931, 1720 Days	Dec. 14, 1931, 1750 Days	Jan. 13, 1932,[a] 1780 Days	Aug. 12, 1932 1990 Days	Group	Average	Group Average
		20	3			4	2		22			7																				A Z Z1	854.3 720.8 624.2	733.1 days
	202, 202, 204		31 206 301				303				303		303		9 206			303														I Z2 Z3	702.0 887.8 1045.5	878.4 days
			12 420										11				419		29	12						16	12				11	B F O Z4	1325.7 1104.3 664.8 662.5	939.3 days
			16 501, 503, 504 605, 606, 606, 607		17 11 606	2 503		504			20		11 17		10, 11	12 1	13, 20	22, 24	9	14 18	20					4	19		12			B G H M T Z5 Z6	1329.3 1205.8 979.3 1074.0 1257.3 898.8 829.7	1082.0 days
13			2	25				18	4			6						8		8	28	23 5			19	10	17			20 17		D S X	1344.8 1314.8 1091.8	1250.5 days
									6	18				14				20 15		16, 22			24	21				18 27 23	19, 25	8, 10		C U V	1379.3 1420.8 1458.5	1419.5 days
					8	15									30																	K	782.0	782.0 days
			2	12	8				10			6																				E	937.3	937.3 days
			6																													Y	605.1	605.1 days
1	3	1	17	2	5	4	2	2	4	1	2	3	4	1	5	2	3	6	2	6	2	2	1	1	1	3	3	3	3	4	1			
51	54	55	72	74	79	83	85	87	91	92	94	97	101	102	107	109	112	118	120	126	128	130	131	132	133	136	139	142	145	149	150			

served, the following 12 failures having occurred since the 18 failures recorded in the 1932 report:[1]

July 5, 1932.—Specimens ZZ-422 (non-copper-bearing open-hearth steel, Youngstown Sheet and Tube Co.) Series B; DD-42 (low-copper pure iron) Series A.

August 5, 1932.—Specimens OO-34 (low-copper open-hearth steel) Series A; XX-16 (low-copper pure iron, Inland Steel Co.) Series B.

September 5–12, 1932.—Specimens AA-31 (non-copper-bearing bessemer steel) Series A; MM-27 (non-copper-bearing open-hearth steel, Alan Wood Steel Co.) Series B; CCC-21 (copper-bearing pure iron) Series A; KK-26 (copper-bearing, acid open-hearth steel) Series A.

December 6, 1932.—Specimens FF-11 (non-copper-bearing open-hearth steel) Series A; HH-37 (copper-bearing, basic open-hearth steel) Series A; HH-44 (copper-bearing, basic open-hearth steel) Series A.

January 5, 1933.—Specimen SS-27 (low-copper pure iron, American Rolling Mill Co.) Series B.

The subcommittee, at its meeting on March 6, 1933, adhered to its previous opinion that no official conclusion should be drawn from the salt water immersion tests until completion of the tests on the No. 16 gage specimens.

Riveted Test Plates.—The riveted test plates exposed at Portsmouth, N. H., July 16, 1926, are being inspected annually, the last inspection having been made September 7, 1932. The plates were inspected before and after being washed, scrubbed, wire-brushed and sandblasted. Wax impressions for electroplating were made after sandblasting from the rivet point side of the plates. Copper replicas are on file in the Bureau of Construction and Repair, Navy Department, up to and including the inspection of October 2, 1931. Examination of these shows spongy corrosion and pitting about equally divided among the rivets, none having progressed to an advanced stage. All calked rows appear in better condition than the others. It is too early, however, to draw definite conclusions. Copper replicas of the September, 1932, inspection have not been received and are not included in this report.

The riveted test plates, exposed at Key West, Fla., September 27, 1926, were raised January 4, 1933, sandblasted, photographed, and wax impressions made of the rivet point sides of the plates. The copper replicas of this inspection have not as yet been received. Copper replicas, however, are on file in the Bureau of Construction and Repair, Navy Department, up to and including the inspection of January, 1932. Examination of these shows pitting and spongy corrosion about equally divided among the various rows of rivets.

The riveted test plates exposed at Port Arthur, Tex., through the cooperation of Mr. James French, of Lloyd's, were immersed

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 107 (1932).

July 26, 1926, and are being inspected by a representative of Lloyd's. Photographs showing corrosive action as of the last inspection on October 30, 1931, were submitted in the 1932 report.[1] Copper replicas covering this inspection are on file in the Bureau of Construction and Repair, Navy Department. No definite conclusions will be drawn at this time.

Chemical analyses of the above rivets and plates appeared in the 1932 report.[2]

Rivet Tests in Ships.—Tests of rivets and plates in oil tankers, under the supervision of Mr. James French of Lloyd's are in progress, the latest report of which is submitted in the 1932 report.[3] Valuable results may be expected upon completion of these tests.

Copper-Bearing and Non-Copper-Bearing Steel Tubes.—The tubes immersed in crates at the Key West Naval Station and the Portsmouth Navy Yard on the same dates as the riveted test plates have been inspected concurrently with the test plates. The tubes installed in the boxes with the sheet-steel specimens at the time these were submerged at the above locations have been inspected at each monthly inspection of the sheet specimens. A description of these tests is given in the 1927 report.[4] No definite report as to relative corrosion can be made from the results reported to date.

Since the tests on the No. 22 gage sheets both at Key West, Fla., and Portsmouth, N. H., have been completed, the boxes in which these sheets were immersed are available for further use. The subcommittee decided to run some additional tests in these boxes to check up on certain variables which may have been present in the original tests. The details of this new series of tests have been worked out by a special subcommittee and are now under consideration by Subcommittee V.

This report has been submitted to letter ballot of the subcommittee and unanimously approved.

Respectfully submitted on behalf of the subcommittee,

F. B. OLCOTT,
Chairman.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, pp. 108, 109 (1932).
[2] *Ibid.*, p. 109 (1932).
[3] *Ibid.*, pp. 108, 109 (1932).
[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 27, Part I, p. 183 (1927).

REPORT OF SUBCOMMITTEE VI ON SPECIFICATIONS FOR METALLIC-COATED PRODUCTS

During the year, Subcommittee VI has concerned itself mainly with the discussion of six tentative specifications for galvanized wire and wire products which have been published for one year and are designed to replace the existing standards for these products.

The following action on these specifications was taken at the spring meeting of the subcommittee which was held at the Hotel New Yorker in New York City on March 8, 1933. Subject to approval by letter ballot of the subcommittee, it was voted to advance the following three tentative specifications to standard to supersede the corresponding present standard specifications and, following their adoption by the Society as standards, to submit them to the American Standards Association for consideration as American Standards:

Tentative Specifications for Zinc-Coated (Galvanized) Iron or Steel Telephone and Telegraph Line Wire (A 111 - 32 T);

Tentative Specifications for Zinc-Coated (Galvanized) Iron or Steel Tie Wires (A 112 - 32 T); and

Tentative Specifications for Zinc-Coated (Galvanized) Iron or Steel Wire Strand (Cable) (A 122 - 32 T).

In line with action taken at the annual meeting in June, 1932, it was voted to revise the Tentative Specifications for Zinc-Coated Iron or Steel Chain-Link Fence Fabric Galvanized After Weaving (A 117 - 32 T) to make it plain that the use of a bend or mandrel test for determining the adherence of zinc coating on chain-link fence fabric galvanized after weaving is not favored. It is accordingly recommended that the specifications be revised by the addition of the following Note after Section 10:

NOTE.—*Adherence of Coating.*—No bend or mandrel test is specified for adherence of the zinc coating on chain-link fence fabric, galvanized after weaving, in the interest of facilitating the manufacture of fabric carrying an adequately heavy coating. The service to which this fabric is put does not require bending it to a degree which justifies the use of a bend or mandrel test to evaluate serviceability of the product.

As amended above and subject to approval by letter ballot of the subcommittee, it was voted to advance these tentative specifications to standard to supersede the existing standard A 117 - 30 and, following their adoption by the Society as standard, to submit them to the American Standards Association for consideration as American Standard.

The subcommittee recommends that the following tentative specifications proposed last year as tentative revisions of the existing standards be continued as tentative:

Tentative Specifications for Zinc-Coated (Galvanized) Iron or Steel Farm-Field and Railroad Right-of-Way Wire Fencing (A 116 – 32 T);

Tentative Specifications for Zinc-Coated (Galvanized) Iron or Steel Barb Wire (A 121 – 32 T).

It was voted to refer these specifications back to the sub-subcommittee for reconsideration and redrafting along the following lines:

1. Careful consideration is to be given to the possibility of specifying more than one grade of farm-field fencing. The viewpoints expressed at the March meeting relating to the following two items will be submitted to the committee on revision for their consideration: (*a*) dissatisfaction, expressed by farmer representatives, with serviceability of fencing conforming to the requirements of Tentative Specifications A 116 – 32 T, and (*b*) opinions expressed by a few manufacturers that in considering possible grades of fencing which might be covered in a specification only such weights of coating as are now commercially available be included.

2. The present tentative specifications for barb wire will be reviewed by the drafting committee in the light of the above-mentioned discussion of the questionable serviceability of material now conforming to the requirements of the existing tentative specifications.

3. Specification requirements for barb wire galvanized after weaving will be formulated by this special committee and recommendations made to Subcommittee VI that: (*a*) These requirements be made the basis for a separate specification, or (*b*) that they be included as a section of a specification for barb wire covering both types of product.

The committee approved the suggestion that the personnel of the subcommittee which drafted the present tentative specifications for farm-field fencing and barb wire be revised at this time. This is being done to obtain on the committee representatives of certain farm bureaus who are actively interested in the type of specification eventually developed to cover these products but who have previously had no representation on the committee.

This report has been submitted to letter ballot of the subcommittee which consists of 44 members; 29 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the subcommittee,

F. F. FARNSWORTH,
Chairman.

REPORT OF SUBCOMMITTEE VIII ON FIELD TESTS OF METALLIC COATINGS

Subcommittee VIII has held one general meeting since the 1932 annual meeting of the Society. Its activities and the results of its investigations are shown under proper subjects below.

GALVANIZED SHEETS

A Special Committee on Inspection of Galvanized Sheets, under the chairmanship of Mr. M. E. McDonnell, has made several inspections during the year.

The dates on which the sheet specimens at Altoona, Pa., Pittsburgh (Brunot Island), Pa., and Sandy Hook, N. J., were inspected are shown in Tables I, II, and III. The number of coating failures found at these inspections is also shown in the tables.

The sheet specimens at State College, Pa., were inspected on April 26, 1932, and October 25, 1932. One of the fourteen specimens of 0.75-oz. coatings on No. 22-gage sheets was found rusted on October 25, 1932, or after 6.51 years' exposure.

The specimens at Key West, Fla., were inspected on January 5, 1933, by Mr. H. E. Smith. They had been exposed 6.57 years at the time. At this location the galvanized sheets are covered with a white basic carbonate coating which evidently has considerable protective value. There are no yellowed areas visible on these sheets.[1]

All of the galvanized sheet specimens at Altoona, Pa., have now rusted and the average time for the first appearance of rust on the specimens is shown in Table I. Four 2.50-oz. coatings on No. 22-gage sheets at Brunot Island have not yet rusted. The failures show that at these two locations the durability of the zinc coatings was substantially proportional to the weight of the coatings.

The progressive development of rust on the zinc-coated sheets at Altoona and Brunot Island is shown in Tables IV and V.[2] The tabulated figures are percentages of exposed areas found to be rusted

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[1] It was stated last year that "yellowed areas" were beginning to show on these sheets. Mr. Smith's inspection was made very carefully; he reports no such condition. The discoloration reported to be "yellow" last year was previously reported as rust blown onto the galvanized sheets from the fence enclosing the test racks.

[2] The data of the Hardware Inspection Committee were shown on this basis in 1931 and will be found continued on pages 154 to 164 of this report. The fact that these tables are comparable will allow the reader to study the performance of the galvanized coatings on sheets with the performance of the coatings on hardware, structural shapes, tubular goods, etc.

TABLE I.—RECORD OF COATING FAILURES ON ALTOONA, PA., TEST RACK. SHEETS EXPOSED APRIL 22, 1926.

Description	Number of Samples in Test	Apr. 7, 1927, 0.96 year	Sept. 28, 1927, 1 43 years	May 1, 1928, 2.03 years	July 27. 1928, 2.27 years	Oct. 30, 1928, 2.53 years	Jan. 28, 1929, 2.77 years	Apr 23, 1929, 3.00 years	July 23, 1929, 3.25 years	Oct. 29, 1929, 3.52 years	Feb. 10, 1930, 3.81 years	Apr. 22, 1930, 4.00 years	July 28, 1930, 4.27 years	Oct. 29, 1930, 4.52 years	Feb. 3, 1931, 4.79 years	Apr. 21, 1931, 5.00 years	July 20, 1931, 5.25 years	Oct. 20, 1931, 5.50 years	Jan. 29, 1932, 5.78 years	Apr. 26, 1932, 6.02 years	July 25, 1932, 6.26 years	Total Number of Failures	Average Life in Years
No. 16 Gage, 2.50 oz. per sq. ft.....	10	none	none	none	none	none	none	none	none	none	none	none	7	2	1	..	..	..	..	..	..	10	4.37
No. 22 Gage, 2.50 oz. per sq. ft.....	18	none	none	none	none	none	none	none	1	2	none	1	5	2	2	none	2	1	1	none	1	18	4.57
No. 22 Gage, 2.00 oz. per sq. ft.....	18	none	none	none	none	none	none	none	6	4	none	none	8	..	..	..	..	..	..	..	..	18	3.76
No. 22 Gage, 1.50 oz. per sq. ft.....	18	none	none	none	2	4	none	1	11	..	..	..	..	..	..	..	..	..	..	..	..	18	2.97
No. 22 Gage, 1.25 oz. per sq. ft.....	18	none	none	none	13	3	none	1	1	..	..	..	..	..	..	..	..	..	..	..	..	18	2 41
No. 22 Gage, 0.75 oz. per sq. ft.....	14	none	6	1	7	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	14	1.89
No. 28 Gage, 0.75 oz. per sq. ft.....	10	none	1	3	6	..	...	..	..	..	..	..	..	..	..	..	..	..	..	..	..	10	2.11
	106	none	7	4	28	7	none	2	19	6	none	1	20	4	3	none	2	1	1	none	1		
Total Failures to Date.........	......	none	7	11	39	46	46	48	67	73	73	74	94	98	101	101	103	104	105	105	106	106	

TABLE II.—RECORD OF COATING FAILURES ON BRUNOT ISLAND, PITTSBURGH, PA., TEST RACK. SHEETS EXPOSED APRIL 21, 1926.

Description	Number of Samples in Test	Apr. 6, 1927, 0.96 year	Sept. 27, 1927, 1.43 years	Apr. 30, 1928, 2.03 years	July 26, 1928, 2.27 years	Oct. 29, 1928, 2.53 years	Jan. 29, 1929, 2.78 years	Apr. 22, 1929, 3.00 years	July 22, 1929, 3.25 years	Oct. 28, 1929, 3.52 years	Feb. 11, 1930, 3.81 years	Apr. 21, 1930, 4.00 years	July 27, 1930, 4.27 years	Oct. 30, 1930, 4.52 years	Feb. 4, 1931, 4.79 years	Apr. 20, 1931, 5.00 years	July 20, 1931, 5.25 years	Oct. 19, 1931, 5.50 years	Jan. 29, 1932, 5.78 years	Apr. 25, 1932, 6.02 years	July 25, 1932, 6.26 years[b]	Total Number of Failures	Average Life in Years
No. 16 Gage, 2.50 oz. per sq. ft.....	12	none	none	none	none	none	none	none	none	none	none	none	1	none	2	1	4	3	1	..	..	12	5.18
No. 22 Gage, 2.50 oz. per sq. ft.....	18	none	none	none	none	none	none	none	none	none	none	1	1	1	none	none	4	4	1	none	2	14	(5.75)[a]
No. 22 Gage, 2.00 oz. per sq. ft.....	18	none	none	none	none	none	none	none	none	1	none	2	3	6	3	none	1	none	2	..	..	18	4.59
No. 22 Gage, 1.50 oz. per sq. ft.....	18	none	none	none	none	none	none	none	10	3	3	1	1	..	..	..	..	..	..	..	..	18	3.49
No. 22 Gage, 1.25 oz. per sq. ft.....	18	none	none	none	none	2	none	none	16	..	..	..	..	..	..	..	..	..	..	..	..	18	3.17
No. 22 Gage, 0.75 oz. per sq. ft.....	14	none	none	5	9	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	14	2.18
No. 28 Gage, 0.75 oz. per sq. ft.....	10	none	none	2	8	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	10	2.22
	108	none	none	7	17	2	none	none	26	4	3	4	6	7	5	1	9	7	4	none	2		
Total Failures to Date.........	......	none	none	7	24	26	26	26	52	56	59	63	69	76	81	82	91	98	102	102	104	104	

[a] Figures shown in parentheses are not to be considered as final.

[b] No additional failures were found at inspections made October 24, 1932 (6.51 years) and January 16, 1933 (6.74 years).

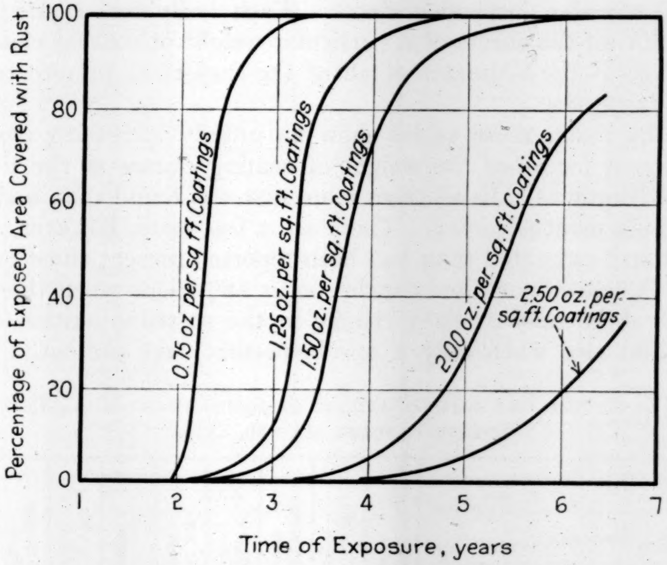

FIG. 1.—Progressive Development of Rust on Zinc-Coated Sheets at Altoona, Pa.

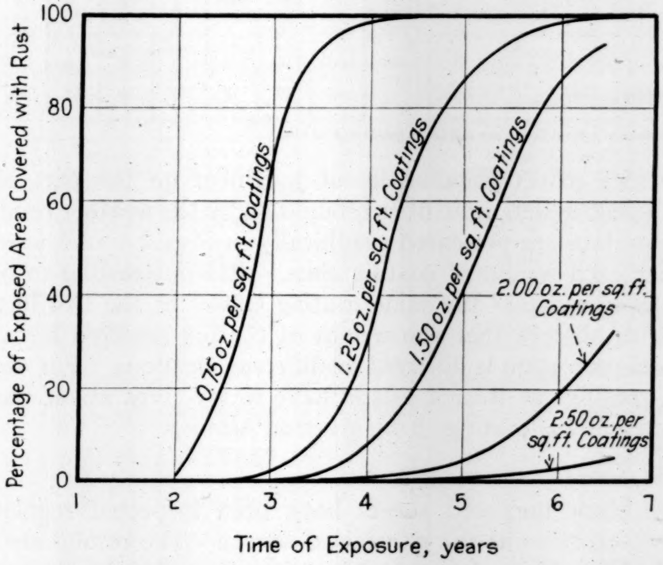

FIG. 2.—Progressive Development of Rust on Zinc-Coated Sheets at Brunot Island, Pittsburgh, Pa.

on the successive inspection dates. Each individual figure is an average for all the sheets of a particular weight of coating class and an average of the estimates of all of the inspectors present on the dates of inspection.

In the main, these tables show an orderly increasing development of rust for all of the weight of coating classes as the time of exposure lengthens. In all cases more rust was found than had been reported six months earlier. There are a few cases, however, where less rust was estimated than had been reported present three months before. These minor discrepancies occur at periods when there had obviously been only a slight change in the rusted condition of the sheets, and also when only a few inspectors were present. These discrepancies reflect peculiarities of judgment on the part of individual inspectors and difficulties brought on by the weather conditions.

TABLE III.—RECORD OF COATING FAILURES ON SANDY HOOK, N. J., TEST RACK. SHEETS EXPOSED MAY 20, 1926.

Description	Number of Samples in Test	Apr. 24, 1930, 3.93 years	Oct. 30, 1930, 4.45 years	Apr. 22, 1931, 4.93 years	Oct. 21, 1931, 5.42 years	Apr. 27, 1932, 5.94 years	Oct. 26, 1932, 6.45 years	Total Number of Failures	Average Life in Years
No. 16 Gage, 2.50 oz. per sq. ft.	10	none	none	none	none	none	none	none	....
No. 22 Gage, 2.50 oz. per sq. ft.	18	none	none	none	none	none	none	none	....
No. 22 Gage, 2.00 oz. per sq. ft.	18	none	none	none	none	none	none	none	....
No. 22 Gage, 1.50 oz. per sq. ft.	18	none	none	none	none	none	1	1	....
No. 22 Gage, 1.25 oz. per sq. ft.	18	none	none	none	1	3	3	7	(6.08)[a]
No. 22 Gage, 0.75 oz. per sq. ft.	14	none	10	1	2	none	1	14	4.77
No. 28 Gage, 0.75 oz. per sq. ft.	10	none	6	1	2	none	1	10	4.89
	106	none	16	2	5	3	6	..	
Total Failures to Date	..	none	16	18	23	26	32	32	

[a] Figures shown in parentheses are not to be considered as final.

These data are presented graphically in Figs. 1 and 2 as smooth curves for each weight of coating class. It is interesting to observe the relative service of the same coating classes at the two locations, and also to observe that the weight of coating required for a given amount of protection is different at different locations. For example, 2.00-oz. coatings at Brunot Island have so far given about the same service as 2.50-oz. coatings have given at Altoona.

Uncoated Sheets:

The black uncoated sheets have been inspected regularly on the same occasions as the galvanized sheets. The results are shown in Table VI. Five of ten sheet specimens at Altoona have failed, seven of ten at Brunot Island, seven of ten at Sandy Hook, none at

TABLE IV.—PROGRESSIVE DEVELOPMENT OF RUST ON ZINC-COATED SHEETS AT ALTOONA, PA. SHEETS EXPOSED APRIL 22, 1926.

Average Percentage of Exposed Areas Rusted at Various Inspections.

Description	Number of Samples in Test	May 1, 1928, 2.03 years	July 27, 1928, 2.27 years	Oct. 30, 1928, 2.53 years	Jan. 28, 1929, 2.77 years	Apr. 23, 1929, 3.00 years	July 23, 1929, 3.25 years	Oct. 29, 1929, 3.52 years	Apr. 22, 1930, 4.00 years	July 28, 1930, 4.27 years	Oct. 29, 1930, 4.52 years	Feb. 3, 1931, 4.79 years	Apr. 21, 1931, 5.00 years	July 20, 1931, 5.25 years	Oct. 20, 1931, 5.50 years	Jan. 30, 1932, 5.78 years	Apr. 26, 1932, 6.01 years	July 25, 1932, 6.26 years	Oct. 25, 1932, 6.51 years	Feb. 20, 1933, 6.75 years
No. 16 Gage, 2.50 oz. per sq. ft........	10	none	none	none	none	none	none	none	none	0.8	2.7	2.8	4.1	7.0	14.0	14.7	18.4	19.5	23.9	37.8
No. 22 Gage, 2.50 oz. per sq. ft........	18	none	none	none	none	none	0.1	0.3	0.5	2.5	4.6	3.2	5.6	7.1	15.7	18.4	21.1	23.5	24.6	40.8
No. 22 Gage, 2.00 oz. per sq. ft........	18	none	none	none	none	none	0.8	1.9	2.2	13.0	21.9	16.8	23.8	38.0	60.7	69.3	74.5	79.1	82.8	89.7
No. 22 Gage, 1.50 oz. per sq. ft........	18	none	0.1	0.8	0.8	1.9	19.4	42.8	57.5	82.7	94.5	97.5	97.1	98.7	99.4	99.7	99.7	100	..	..
No. 22 Gage, 1.25 oz. per sq. ft........	18	none	0.8	3.5	4.1	11.2	66.7	85.0	93.5	98.1	99.6	100	..	..	..	..	..	..	..	..
No. 22 Gage, 0.75 oz. per sq. ft........	14	3.4	75.4	83.2	88.4	94.1	99.9	100	..	..	..	..	..	..	..	..	..	..	..	..
No. 28 Gage, 0.75 oz. per sq. ft........	10	1.7	74.3	85.1	92.3	98.4	100	..	..	..	..	..	..	..	..	..	..	..	..	..

TABLE V.—PROGRESSIVE DEVELOPMENT OF RUST ON ZINC-COATED SHEETS AT BRUNOT ISLAND, PITTSBURGH, PA. SHEETS EXPOSED APRIL 21, 1926.

Average Percentage of Exposed Areas Rusted at Various Inspections.

Description	Number of Samples in Test	Apr. 30, 1928, 2.03 years	July 26, 1928, 2.27 years	Oct. 29, 1928, 2.53 years	Jan. 29, 1929, 2.78 years	Apr. 22, 1929, 3.00 years	July 22, 1929, 3.25 years	Oct. 28, 1929, 3.52 years	Feb. 11, 1930, 3.81 years	Apr. 21, 1930, 4.00 years	July 27, 1930, 4.27 years	Oct. 30, 1930, 4.52 years	Feb. 4, 1931, 4.79 years	Apr. 20, 1931, 5.00 years	July 20, 1931, 5.25 years	Oct. 19, 1931, 5.50 years	Jan. 29, 1932, 5.78 years	Apr. 25, 1932, 6.01 years	July 25, 1932, 6.26 years	Oct. 24, 1932, 6.51 years	Jan. 16, 1933, 6.73 years
No. 16 Gage, 2.50 oz. per sq. ft.	12	none	none	none	none	none	none	none	none	none	0.1	0.1	0.3	0.3	0.8	1.6	2.1	3.8	3.3	5.5	5.6
No. 22 Gage, 2.50 oz. per sq. ft.	18	none	none	none	none	none	none	none	none	0.1	0.1	0.2	0.2	0.2	0.6	1.2	2.7	3.1	2.2	4.6	5.1
No. 22 Gage, 2,00 oz. per sq. ft.	18	none	none	none	none	none	none	0.1	0.1	0.4	0.5	1.2	2.1	3.1	6.2	10.2	14.9	23.2	18.8	28.9	36.9
No. 22 Gage, 1.50 oz. per sq. ft.	18	none	none	none	none	0.1	0.7	1.6	2.4	8.8	15.6	26.0	28.2	44.1	53.9	70.7	81.2	90.3	88.6	93.4	96.0
No. 22 Gage, 1.25 oz. per sq. ft.	18	none	none	0.1	0.3	0.5	4.8	11.4	19.0	42.9	60.6	73.8	79.2	81.6	91.5	97.0	98.4	99.4	98.4	99.7	100
No. 22 Gage, 0.75 oz. per sq. ft.	14	0.9	8.8	27.8	33.8	53.0	86.7	91.6	98.2	99.2	99.4	100	..	..	..	..	..	..	..	..	..
No. 28 Gage, 0.75 oz. per sq. ft.	10	1.3	14.3	31.8	46.4	69.1	89.9	95.9	98.6	99.6	99.8	100	..	..	..	..	..	..	..	..	..

State College, and all ten at Key West. These tests show conclusively that the relative resistance to corrosion of zinc and iron varies with different locations.

TABLE VI.—TIME IN YEARS FOR PERFORATIONS OF NO. 22 GAGE, BLACK SHEETS.[a]

Identification	Class of Material	Average Chemical Composition									Brunot Island, Pittsburgh, Pa.	Altoona, Pa.	Key West, Fla.	Sandy Hook, N. J.	State College, Pa.
		Carbon, per cent	Manganese, per cent	Phosphorus, per cent	Sulfur, per cent	Silicon, per cent	Copper, per cent	Nickel, per cent	Chromium, per cent	Molybdenum, per cent					
R	Open-Hearth Iron.......	0.011	0.021	0.004	0.018	0.004	0.032	0.023	[d]	0.004[b]	2.03	4.27	3.62	5.94	—
V	Open-Hearth Iron.......	0.018	0.053	0.005	0.032	0.004	0.051	0.045	[d]	0.007[b]	2.27	4.27	3.62	4.93	—
U	Open-Hearth Iron.......	0.015	0.020	0.004	0.024	0.005	0.087	0.106	[d]	0.009[b]	2.53	4.27	3.62	5.42	—
N	Open-Hearth Iron.......	0.013	0.057	0.007	0.029	0.003	0.167	0.057	[d]	0.004[b]	3.00	—	3.62	5.94	—
T	Open-Hearth Iron.......	0.016	0.157	0.007	0.028	0.004	0.228	0.073	[d]	0.004[b]	—	—	3.62	6.45	—
Y	Open-Hearth Steel......	0.028	0.346	0.067	0.050	0.005	0.029	0.003[b]	0.013	[c]	2.03	2.03	2.62	3.45	—
S	Open-Hearth Steel......	0.040	0.488	0.072	0.041	0.003	0.051	0.006[b]	0.094	[c]	3.25	—	3.62	—	—
C	Open-Hearth Steel......	0.066	0.458	0.053	0.045	0.003	0.222	0.003[b]	0.000[b]	[c]	—	—	5.73	—	—
K	Open-Hearth Steel......	0.023	0.460	0.066	0.045	0.003	0.268	0.023[b]	0.031	[c]	—	—	4.58	—	—
W	Wrought Iron...........	0.021	0.048	0.143	0.019	0.210	0.025	0.020[b]	[d]	0.003[b]	3.00	5.00	3.62	4.93	—

[a] Blanks in table represent sheets that have not failed as yet. The material has been under observation for $6\frac{3}{4}$ years.

[b] Average of determinations in one laboratory.

[c] Less than 0.003 per cent; results of one laboratory.

[d] Less than 0.006 per cent; results of one laboratory.

COATED HARDWARE, STRUCTURAL SHAPES, TUBULAR GOODS, ETC.

A Special Committee on Inspection of Coated Hardware, Structural Shapes, Tubular Goods, etc., under the chairmanship of Mr. W. L. Maucher, has made several inspections during the past two years, the results of which are shown in Table VII. These tables cover the following eight types of coatings which were applied to the various shapes by commercial operations:

1. Hot-dipped zinc
2. Electrodeposited zinc
3. Sherardized (zinc) applied in gas-heated drum
4. Sherardized (zinc) applied in electrically heated drum
5. Electrodeposited cadmium
6. Hot-dipped aluminum
7. Hot-dipped lead (Amaloy)
8. Parkerized

It will be noted that four of these are zinc coatings representing as many processes.

It will be found upon an examination of Table VII that the weight of coating applied by a given process was not the same on all the shapes. The committee is in no position to say that commercial articles similar in kind and shape to those included in this test will carry the weight of coating found on them in this test. This is not a test of commercial products but of protective coatings which were applied by commercial operations to a variety of iron and steel base articles, some of which may incidentally be like those bought and sold in the market. In this test the basic article is present only as a carrier of the coating and is not being tested as a commercial product. From data which have been reviewed on the weight of coating applied by the various processes, the committee is of opinion that the *range of weights of coating* found in these tests is about the same as the range of weights of coating applied by commercial operations.

At the time these tests were started, there was a definite demand for a knowledge of the relative service of coatings containing little or no zinc-iron compounds and those which are almost exclusively zinc-iron compounds. The committee refers readers interested in this question to the data contained in the accompanying tables and to those included in the report of the Galvanized Sheet Inspection Committee.[1] *Care should be taken to compare the same weight of coating applied by the various processes.* As the result of such a study, the committee is of opinion that sherardized, hot-dipped, and plated-zinc coatings of the same weight have approximately the same service life, provided the article is so shaped that the zinc or zinc-iron compounds can be distributed with equal uniformity by the various processes. This conclusion is substantiated by data published in the technical literature from other sources.[2,3]

While it is possible to apply the same weight of zinc coating by the various processes used for this operation, it happens that usually in practice a heavier coating is applied by hot dipping than by the other processes as they are normally conducted. In the selection of a weight of coating for specification, it is oftentimes necessary to consider corrosion resistance and some other requisite; for example, ability to be formed, bent, etc. Thus, it may not always be advisable to select the heaviest weight of coating available or the coating process which normally applies the heaviest coating. The data included in this report are not intended to be a guide for the selection of finishes for indoor service, or appearance, or for any other property of the coatings except resistance to outdoor corrosion. No coating process should be considered better or worse than another without taking into account the weight and uniformity of coating, subsequent processing of the products and installation requirements.

From the accompanying Table VII and from observations which have been made by the Inspection Committee, the following state-

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[1] Weight of coating in the report of the Galvanized Sheet Inspection Committee, pages 149 to 154, is given in ounces per square foot of sheet in accordance with trade practice. This figure should be divided by two to convert it to ounces per square foot of surface in which units the weight of coating is expressed on hardware and in this section of the report.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part II, p. 456 (1930).

[3] *Transactions*, Am. Electrochemical Soc., Vol. 58, p. 23 (1930).

TABLE VII.—REPORT ON INSPECTIONS OF METALLIC COATINGS ON HARDWARE, STRUCTURAL SHAPES, TUBULAR GOODS, ETC. EXPOSED TO ATMOSPHERE ON TEST RACKS AT FIVE LOCATIONS.

Abbreviations and Symbols Used: 0 - no rust; 5, 10, 25, 100 - approximate percentages; R - rusting of base metal; Y - yellow or orange alloy rust; * - rust spots widely distributed; d - black or dark surface film (soot or dirt); a - in angle; < - less than; e - edges; th - threads; sl - slight; n - near; s - stain.

Coating	Weight, oz. per sq. ft. of surface	Exposure at Brunot Island, Pa.				Exposure at Altoona, Pa.				Exposure at State College, Pa.				Exposure at Sandy Hook, N. J.				Exposure at Key West, Fla.	
		120 Weeks	146 Weeks	173 Weeks	199 Weeks	121 Weeks	147 Weeks	174 Weeks	200 Weeks	120 Weeks	146 Weeks	173 Weeks	199 Weeks	121 Weeks	147 Weeks	174 Weeks	200 Weeks	162 Weeks	206 Weeks
3 BY 3 BY $\frac{5}{16}$-IN. PLAIN STEEL ANGLES																			
Electro Galvanized	0.52	46Ra	60Ra	60R	63R	20Ra	28Ra	24R	25R	0	0	0	0	<10Ra	<10Ra	<10Ra	<10Ra	slR	slR
Hot Dip Galvanized	2.52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Dip Aluminum	0.89	0d	0d	0d	0d	0d	0d	0d	0d	0	0	0	0	0	0	0	0	0	0
Cadmium Plated	0.09	100R	100R	100R	100R	100R	100R	100R	100R	79R	91R	92R	95R	100R	100R	100R	100R	70Ra	82Ra
Electric Sherardized	1.38	0d	0d	100Y	12R-88Y	0d	<10nR	100Y	100Y	0d	0d	0d	slY	1R	0	<10R	100Y	13R	slY
Lead Plated	....	16R	15R	49R	40R	0d	<10R	0d	0d	58R	59R	66R	71R*	65R	58R	55R	57R	67R	40R
3 BY 3 BY $\frac{5}{16}$-IN. COPPER-BEARING STEEL ANGLES																			
Electro Galvanized	0.37	34Ra	39Ra	50R	50R	30Ra	36Ra	42Ra	45R	0	0	0	slR	<10R	<10R	<10R	<10R	slR	0
Hot Dip Galvanized	2.88	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	slR	0
Hot Dip Aluminum	0.82	0d	0d	0d	0d	0d	0d	0d	0d	0	0	0	0	0	0	0	0	0	0
Cadmium Plated	0.24	100R	100R	100R	100R	100R	100R	100R	100R	14R	20R	28R	30R	55Ra	73R	78R	73R	11R	18R
Electric Sherardized	1.44	0d	0d	slY	100Y	0d	0d	77Y	100Y	0d	0d	slY	75Y	slY	slY	slY	100Y	13Y	<10Y
Lead Plated	....	13R	13R-60Y	49R	69R	0d	<10R	0d	0d	63R	50R	54R	53R	73R	73R	74R	75R	60R	55R
2 BY $1\frac{1}{2}$ BY $\frac{3}{16}$-IN. PLAIN STEEL ANGLES																			
Electro Galvanized	0.53	76R	80R	81R	85R	66R	70R	70R	70R	<10Ra	<10Ra	<10Ra	<10Ra	<10R	11R	14R	18R	<10R	<10R
Electro Galvanized	0.50	76R	82R	88R	100R	53Ra	80Ra	97R	100R	0	0	1R	<10R	1R	<10R	10R	12R	<10R	<10Y
Hot Dip Galvanized	3.24	0	0	0	0d	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Dip Aluminum	0.76	0d	0d	0d	0d	0d	0d	0d	0d	0	0	0	0	0	0	0	0	<10R	15Y
Cadmium Plated	0.43	100R	100R	100R	100R	100R	100R	100R	100R	18R	32R	31R	38R	31Ra	49Ra	71R	71R	14R	13Ra
Electric Sherardized	1.21	0d	75R	77R	88R	0	67R	67R	82R	<10R-50Y	<10R-90Y	20R-80Y	100Y	100Y	<10R-90Y	<10R-90Y	100nR	100Y	13R-88Y
Lead Plated	....	<10R	<10R	23R	36R	0	0d	0d	0d	50R	50R	48R	52R*	42R*	32R*	31R*	60R*	17R	<10R
2 BY $1\frac{1}{2}$ BY $\frac{3}{16}$-IN. COPPER-BEARING STEEL ANGLES																			
Electro Galvanized	0.70	74R	78Ra	80R	80R	54R	54R	66R	66R	0	0	0	0	<10Ra	<10Ra	<10Ra	13Ra	1R	slR
Electro Galvanized	0.76	19R-22Y	43Ra	63R	70R	20R-18Y	53R	58R	61R	<10R	<10R	<10R	<10R	10Ra	13Ra	13Ra	11Ra	<10R	<10R
Hot Dip Galvanized	2.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Dip Aluminum	0.50	0d	0d	0d	0d	0d	0d	0d	0d	0	0	0	0	0	0	0	0	0	<10Y
Cadmium Plated	0.50	100R	100R	100R	100R	100R	100R	100R	100R	<10R	<10R	<10R	<10R	63Ra	70Ra	72Ra	72Ra	18R	20R
Electric Sherardized	1.15	3R	80R-20Y	81R	89R	0	43R	45R	63R	100R	100R	100R	100R	100Y	<10R-90Y	<10R-90Y	100nR	100R	100R
Gas Sherardized	0.17	100R	100R	100R	100R	100R	100R	100R	100R	27R	49R	47R	47R*	100R	100R	100R	100R	100R	100R
Lead Plated	....	4R	<10R	12R	15R	0d	<10R	0d	0d	....	....	....	....	12R*	17R*	17R*	30R*	23R	10R

2-IN. DIAMETER TUBULAR GOODS

Electro Galvanized	1.58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Dip Galvanized	2.51	0	0	0	0	0	0	slY	slY	0	0	0	0	0	0	0	0	0	0
Hot Dip Aluminum	4.73	0d	0d	0d	0d	0d	0d	0d	0d	0	0	0	0	0	0	0	0	<10R	<10Y
Cadmium Plated	0.23	100R	100R	100R	100R	100R	100R	100R	100R	0	1R	1R	<10R	33R	55R	72R	83R	<10R	<10R
Cadmium Plated	0.10	100R	100R	100R	100R	100R	100R	100R	100R	<10R	16R	16R	24R	90R	91R	92R	99R	<10R	<10R
Electric Sherardized	0.29	100R	100R	100R	100R	100R	100R	100R	100R	0d	<10R	<10R	<10R	36R	91R	97R	99R	<10Y	slR - 95Y
Electric Sherardized	0.85	100R	100R	100R	100R	100R	100R	100R	100R	0d	<10R	<10R	<10R	52R	92R	98R	99R	<10Y	95Y
Gas Sherardized	0.66	0d	0d	0d	1R	0d	0d	0d	10R	0d	0d	0d	0d	0	0d	0d	100Y	<10Y	90Y
Lead Plated	....	5R	13R	15R	10R	0d	16R	0d	0d	32R	60R	64R	77R*	13R*	25R*	30R*	43R*	20R	14R

1-IN. DIAMETER TUBULAR GOODS

Electro Galvanized	1.62	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Dip Galvanized	1.83	0	0	0	0	0	0	83Y	100Y	0	0	0	0	0	0	0	0	0	0
Hot Dip Aluminum	1.83	0d	0d	0d	0d	0d	0d	0d	0d	0	0	0	0	0	0	0	0	<10R	0
Cadmium Plated	0.30	100R	100R	100R	100R	100R	100R	100R	100R	39R	60R	72R	80R	[a]	[a]	[a]	[a]	72R	75R
Cadmium Plated	0.18	100R	100R	100R	100R	100R	100R	100R	100R	12R	12R	12R	12R	[a]	[a]	[a]	[a]	0	0
Electric Sherardized	0.42	100R	100R	100R	100R	100R	100R	100R	100R	62R	63R	67R	67R	[a]	[a]	[a]	[a]	87R	96R
Electric Sherardized	0.92	0d	<10R	<10R	<10R	0d	27R	27R	27R	0d	0d	0d	68Y	[a]	[a]	[a]	[a]	<10Y	43Y
Gas Sherardized	0.72	0d	0d	0d	0d	0d	<10R	<10R	21R	0d	0d	100Y	100Y	[a]	[a]	[a]	[a]	slR 75Y	100Y
Calorized	....	0d	0d	0d	0d	0d	0d	0d	0d	slY	slY	100Y	100Y	[a]	[a]	[a]	[a]	75R	50R - 50Y
Lead Plated	....	<10R	10R	10R	17R	0d	32nR	0d	0d	10R	26R	35R	34R	[a]	[a]	[a]	[a]	25R	<10R - 15Y
Amaloy	....	<10R	15R	17R	32R	0d	32nR	0d	0d	45R	53R	60R	63R	[a]	[a]	[a]	[a]	<10R	<10R

FORGED STEEL TOWER FITTING

Electro Galvanized Bolt	0.31	28R	40R	63R	72R	23R	39R	65R	61R	0	0	0	0	0	0	0	0	0	slR
Nut	0.54																		
Clamp	1.15																		
Electro Galvanized Bolt	0.02	55R	52R	64R	65R	69R	82R	86R	93R	0	0	0	0	0	<10R	<10R	<10R	0	0
Nut	0.01																		
Clamp	0.46																		
Hot Dip Galvanized	2.67	0	0	17Y	36Y	0	0d	20Y	20Y	0	0	0	0	0	0	0	0	<10R	<10R
Hot Dip Galvanized	1.53	0d	0d	35Y	<10R 98Y	<10Y	16Y	56Y	35Y	0	0	0	0	0	0	0	0	0	0
Hot Dip Aluminum	....	0	0d	0d	0d	0	0d	0d	0	0	0	0	0	0	0	0	0slY	30R	<10R - 22Y
Cadmium Plated	1.40	100R	100R	100R	100R	100R	100R	100R	100R	<10R	<10R	<10R	<10R	25R	85R	100R	100R	10R	<10R
Electric Sherardized	0.50	slY	slY	slY	slY	0d	0d	0d	1R	0	0d	0d	60Y	0	0	0	slY	<10Y	10Y
Gas Sherardized	....	17R	74R	81R	77R	0d	18R	25R	35R	100Y	100Y	100Y	100Y	0d	100Y	100Y	100Y	50R	85Y
Parkerized	....	28R	51R	62R	60R	<10R	<10R	27R	15R	77R	94R	98R	100R	81R	80R	95R	93R	100R	100R
Cadmium Plated	0.26	80R	100R	100R	100R	100R	100R	100R	100R	0	<10R	<10R	<10R	<10R	15R	15R	20R	<10R	<10R
Lead Plated	....	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R

[a] These specimens missing. They were lost when the rack broke down.

PRINT IN BIN

TABLE VII.—REPORT ON INSPECTIONS OF METALLIC COATINGS, ETC. (*Continued*).

Abbreviations and Symbols Used: 0 - no rust; 5, 10, 25, 100 - approximate percentages; R - rusting of base metal; Y - yellow or orange alloy rust; * - rust spots widely distributed; d - black or dark surface film (soot or dirt); a - in angle; < - less than; e - edges; th - threads; sl - slight; n - near; s - stain.

Coating	Weight, oz. per sq. ft. of surface	Exposure at Brunot Island, Pa.				Exposure at Altoona, Pa.				Exposure at State College, Pa.				Exposure at Sandy Hook, N. J.				Exposure at Key West, Fla.	
		120 Weeks	146 Weeks	173 Weeks	199 Weeks	121 Weeks	147 Weeks	174 Weeks	200 Weeks	120 Weeks	146 Weeks	173 Weeks	199 Weeks	121 Weeks	147 Weeks	174 Weeks	200 Weeks	162 Weeks	206 Weeks
¾-IN. NIPPLES AND ELLS																			
Electro Galvanized, MI[a] ..... Nipple	1.64	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ell	1.55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	slY	0	0	0
Electro Galvanized, CI[b] ..... Nipple	2.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ell	2.36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	slY	0	0	0
Electro Galvanized, MI...... Nipple	2.43	36R	46R	67R	67R	30Y	43R	65R	71R	0	0	0	0	0	0	0	0	0	slR
Ell	2.90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Electro Galvanized, CI ...... Nipple	1.82	32R	43R	52R	50R	10R	37R	50R	51R	0	0	0	0	0	0	0	0	0	0
Ell	0.67	0	0	0	0	20Y	0	0	0	0	0	0	0	0	0	slY	0	0	0
Hot Dip Galvanized, MI........	1.82	0	0d	slY	slY	0	0	27Y	75Y	0	0	0	0	0	0	0	0	0	0
Hot Dip Galvanized, CI........	1.44	0	0	slY	slY	0	0	30Y	75Y	0	0	0	0	0	0	0	0	0	0
Hot Dip Aluminum, MI........	3.20	0	0	0	0d	0	0d	0d	0d	<10R	<10R	<10R	<10R	<10R	<10R	<10R	<10R	30R	30R
Hot Dip Aluminum, CI........	2.80	0	0	0	0d	0d	0d	0d	0d	<10R	<10R	<10R	<10R	<10R	<10R	<10R	<10R	30R	30R
Cadmium Plated, MI...........	....	100R	100R	100R	100R	100R	100R	100R	100R	0	<10R	<10R	<10R	60R	98R	100R	100R	10R	<10R
Cadmium Plated, CI...........	....	100R	100R	100R	100R	100R	100R	100R	100R	0	11R	10R	23R	100R	100R	100R	100R	<10R	<10R
Cadmium Plated, MI...........	....	0	14R	23R	30R	100R	100R	100R	100R	0	0	0	<10R	65R	100R	100R	100R	<10R	<10R
Cadmium Plated, CI...........	....	0	18R	22R	37R	100R	100R	100R	100R	0	<10R	<10R	18R	100R	100R	100R	100R	<10R	<10R
Electric Sherardized, MI........	0.63	<10R	24R	35R	35R	0	<10R	<10R	31R	0	slY	slY	33Y	slY	100Y	100Y	100Y	50Y	77Y
Electric Sherardized, CI........	0.47	38R	81R	90R	93R	0	<10R	<10R	38R	33Y	75Y	100Y	100Y	slY	100Y	100Y	100Y	42Y	70Y
Gas Sherardized, MI...........	0.78	<10R	36R	45R	66R	17R	43R	55R	68R	67Y	83Y	100Y	100Y	slY	<10R - slY	11R - 33Y	11R - 89Y	83Y	10R - 75Y
Gas Sherardized, CI............	0.84	<10R	<10R	17R	17R	15R	43R	62R	68R	100Y	100Y	100Y	100Y	25R	30R	32R	43R	100R	40R - 60Y
Parkerized, MI................	....	0	<10R	<10R	<10R	0	<10R	<10R	<10R	15R	29R	28R	65R	<10R	12R	20R	20R	100R	100R
Parkerized, CI................	....	0	0	0	0	0	<10R	<10R	<10R	14R	26R	28R	68R	<10R	<10R	18R	20R	100R	100R
Electric Sherardized, MI........	0.75	33R	33R	30R	41R	0	0	0	slY	0	0	0	57Y	0	0	0	100Y	13Y	50Y
Electric Sherardized, CI........	0.82	37R	25R	28R	21R	0	0d	0d	slY	0	slY	slY	83Y	0	0	0	100Y	....	....
Amaloy, MI....................	....	....	....	....	....	0	0	0	0d	70R	81R	81R	93R*	40R	60R	60R	95R*	77R	50R
Amaloy, CI....................	....	....	....	....	....	0	0	0	0d	70R	78R	80R	95R	40R	60R	45R	95R*	70R	50R
TOWER CLAMPS																			
Electro Galvanized, MI[a] ..... Bolt	0.31	<10R	<10R	10R	22R	<10R	16R	41R	35R	0	0	0	0	0	0	0	0	<10R	<10R
Nut	0.54																		
Clamp	1.15																		
Electro Galvanized, CI[b] ..... Bolt	0.28	<10R	32R	47R	80R	27R	73R	77R	77R	0	0	0	0	0	0	0	0	0	0
Nut	0.56																		
Electro Galvanized, MI...... Bolt	0.02	59R	68R	84R	85R	90R	95R	99R	100R	<10R	10R	15R	15R	<10R	<10R	21R	28R	10R	<10R
Nut	0.01																		
Electro Galvanized, CI Bolt	0.04	16R	53R	70R	82R	92R	95R	99R	100R	<10R	10R	15R	15R						
Nut																			

Electro Galvanized, CI	Bolt Nut Clamp	0.04 0.04 0.74	16R	53R	70R	82R	92R	95R	99R	100R	<10R	10R	15R	15R	0	<10R	17R	22R	17R	11R
Hot Dip Galvanized, MI		1.53	0	0	<10Y	10Y	0	<10Y	48Y	75Y	0	0	0	0	0	0	0	0	0	0
Hot Dip Galvanized, CI		1.75	0	0	10Y	10Y	0	0	25Y	75Y	0	0	0	0	0	0	0	0	0	0
Hot Dip Galvanized, MI		2.00	0	0	0	slY	0	0	0	slY	0	0	0	0	0	0	0	0	0	0
Hot Dip Galvanized, CI		2.38	0	0	10Y	10Y	0	0	0	slY	0	0	0	0	0	0	0	0	0	0
Cadmium Plated, MI		0.28	100R	100R	100R	100R	100R	100R	100R	100R	<10R	<10R	14R	20R	96R	100R	100R	100R	<10R	<10R
Cadmium Plated, CI		0.28	100R	100R	100R	100R	100R	100R	100R	100R	0	<10R	<10R	23R	100R	100R	100R	100R	<10R	<10R
Cadmium Plated, MI		0.15	100R	100R	100R	100R	100R	100R	100R	100R	67R	97R	100R	100R	100R	100R	100R	100R	100R	100R
Cadmium Plated, CI		0.17	100R	100R	100R	100R	100R	100R	100R	100R	73R	96R	100R	100R	100R	100R	100R	100R	100R	100R
Electric Sherardized, MI		....	100R	100R	100R	100R	100R	100R	100R	100R	86R	86R	96R	85R	98R	100R	100R	100R	100R	100R
Electric Sherardized, CI		1.82	0	<10R	0	23R	0	0d	0d	slR	0	0	0	55Y	slY	<10R-slY	<10R-slY	<10R-93Y	50Y	25Y
Gas Sherardized, MI		0.50	<10R	33R	43R	54R	0	0d	0d	slR	90Y	95Y	65Y	100Y	100Y	100Y	33R	30R-70Y	20R	slY
Gas Sherardized, CI		0.63	<10R	20R	25R	50R	0	31R	34R	46R	100Y	69R	67R-33Y	63R-37Y	100Y	13R-70Y	15R	30R-70Y	100R	100R
Parkerized, MI		....	53R	100R	100R	100R	<10R	31R	40R	76R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R
Parkerized, CI		....	15R	15R	15R	16R	<10R	22R	20R	32R	17R	50R	67R	70R-30Y	40R	23R	22R	100R	100R	100R
Hot Dip Aluminum, MI		3.16	0	0d	0d	0d	0	0d	0d	0d	0	0	0	0	0	0	0	0	<10R	<10R-<10Y
Hot Dip Aluminum, CI		2.51	0	0d	0d	0d	0	0d	0d	<10R	0	0	0	0	0	0	0d	0	slR	slR
Amaloy, MI		....	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R
Amaloy, CI		....	100R	100R	100R	100R	90R	90R	64R	72R	80R	48R	87R	100R	100R	58R	100R	100R	100R	95R-5Y

1½ BY 1½ BY ⅛-IN. PLAIN STEEL ANGLES

Electro Galvanized	0.47	32R	53R	68R	78R	45R	55R	60R	62R	0	0	0	<10R	<10R	14R	16R	16R	0	0
Electro Galvanized	1.09	0	<10R	<10R	15R	<10Y	26R	31R	49R	0	0	0	0	<10R	<10R	<10R	<10R	slR	slY
Hot Dip Galvanized	3.16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Dip Aluminum	0.89	100R	100R	100R	100R	0d	0d	0d	0d	0	0	0	0	0	0	0	0	slR	0
Cadmium Plated	0.12	<10R	85R	94R	100R	100R	100R	100R	100R	<10R	13R	16R	22R	42R	66R	83R	83R	<10R	<10R
Electric Sherardized	0.14	100R	100R	100R	100R	<10R	67R	66R	69R	31R	33R	33R-67Y	33R-67Y	100Y	100nR	100nR	100nR	50Y	90Y
Gas Sherardized	....	0	0	0	0d	100R	100R	100R	100R	50R	100R	100R	100R	100R	100R	100R	100R	100R	100R
Lead Plated	....	<10R	<10R	<10R	<10R	0	<10Y	<10Y	<10Y	19R	24R	21R	21R*	18R*	20R*	21R*	30R*	33R	<10R

1½ BY 1½ BY ⅛-IN. COPPER-BEARING STEEL ANGLES

Electro Galvanized	0.76	47R	62R	73R	87R	78R	78R	89R	89R	0	<10R	<10R	<10R	<10R	<10R	<10R	10R	0	0
Electro Galvanized	0.47	16R	43R	72R	81R	30R	60R	74R	76R	0	0	0	0	0	0d	<10R	<10R	0	0
Hot Dip Galvanized	3.20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Dip Aluminum	1.11	100R	100R	100R	100R	0d	0d	0d	0d	0	0	0	0	0	0	0	0	slY	slY
Cadmium Plated	0.65	0d	68R	100R	100R	100R	100R	100R	100R	1R	<10R	<10R	<10R	45R	61R	70R	72R	<10Ra	<10Ra
Electric Sherardized	....	....	....	....	....	100Y	52R	65Y	68R	slY	slY	100Y	100R	<10R	100nR	100Y	100nR	50Y	90Y
Gas Sherardized	....	0d	0d	0d	0d	....	....	....	....	28R	42R	32R	58R*	....	....	....	....	....	....
Lead Plated	....	<10R	<10R	<10R	10R	0	<10Y	0d	0d	....	....	....	....	25R	15R	26R	25R	26R	<10R

[a] MI indicates malleable-iron base metal.
[b] CI indicates cast-iron base metal.

TABLE VII.—REPORT ON INSPECTIONS OF METALLIC COATINGS, ETC. (*Continued*).

Abbreviations and Symbols Used: 0 - no rust; 5, 10, 25, 100 - approximate percentages; R - rusting of base metal; Y - yellow or orange alloy rust; * - rust spots widely distributed; d - black or dark surface film (soot or dirt); a - in angle; < - less than; e - edges; th - threads; sl - slight; n - near; s - stain.

Coating	Weight, oz. per sq. ft. of surface	Exposure at Brunot Island, Pa.				Exposure at Altoona, Pa.				Exposure at State College, Pa.				Exposure at Sandy Hook, N. J.				Exposure at Key West, Fla.	
		120 Weeks	146 Weeks	173 Weeks	199 Weeks	121 Weeks	147 Weeks	174 Weeks	200 Weeks	120 Weeks	146 Weeks	173 Weeks	199 Weeks	121 Weeks	147 Weeks	174 Weeks	200 Weeks	162 Weeks	206 Weeks
No. 14 BY 2½-IN. PLAIN STEEL FLATS																			
Electro Galvanized	0.45	87R	99R	98R	100R	92R	97R	99R	100R	0	0	0	0	0	<10R	50R	58R	0	0
Electro Galvanized	0.70	0d	0d	<10R	<10R	0	0d	0d	0d	0	0	0	0	0	0	0	0	0	0
Hot Dip Galvanized	3.16	0	0	<10Y	<10R	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Dip Aluminum	0.89	0	0d	0d	0d	0d	0d	0d	0d	0	0	0	0	0	0	0	0	0	0
Cadmium Plated	....	100R	100R	100R	100R	100R	100R	100R	100R	0	1R	1R	1R	72R	89R	98R	100R	<10R	<10R
Electric Sherardized	0.58	<10R	92R	98R	100R	0d	93R	94R	98R	100Y	100Y	<10R - 97Y	<10R - 98Y	<10R - 95Y	<10R - 95Y	<10R - 95Y	10R - 90Y	63Y	<10R - 75Y
Gas Sherardized	....	0d	15R	50R	51R	0	17R	23R	27R	100Y	100nR	100nR	100nR	slY	<10R - 95Y	<10R - 95Y	13R - 87Y	50Y	90Y
Lead Plated	....	<10R	<10R	<10R	<10R	0	0d	0d	0d	<10R	12R	10R	10R*	<10Re	<10R*	<10R*	30R*	15R	<10R
No. 14 BY 2½-IN. COPPER-BEARING STEEL FLATS																			
Electro Galvanized	0.29	33R	42R	53R	95R	95R	100R	100R	100R	0	0	0	0	0	0	0	<10R	0	0
Electro Galvanized	0.62	0d	<10R	<10R	<10R	0	13R	40R	47R	0	0	0	0	0	0	0	0	0	0
Hot Dip Galvanized	3.20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Dip Aluminum	0.47	0d	0d	0d	0d	0d	0d	0d	0d	0	0	0	0	0	0	0	0	0	0
Cadmium Plated	....	100R	100R	100R	100R	100R	100R	100R	100R	0	0	0	0	36R	43R - 57Y	55R	80R	37R	38R
Electric Sherardized	....	14R	97R	99R	99R	0	77R	100R	100R	<10R - 95Y	<10R - 95Y	<10R - 95 nR	<10R - 96Y	<10R - 90Y	<10R - 90Y	<10R - 97Y	<10R - 97Y	57Y	<10R - 60Y
Gas Sherardized	....	0d	35R	60R	60R	1R	19R	20R	21R	100Y	100Y	100Y	100Y	<10R - 95Y	24R - 76Y	20R - 80Y	38R - 62Y	57Y	67Y
Lead Plated	....	<10R	<10R	<10R	<10R	0d	0d	0d	0d	<10R	10R	10R	10R*	<10R	<10R	<10R	<10R*	15R	<10R
¼ BY 6-IN. BOLTS																			
Sherardized	0.68	0d	0	0	0	0d	0d	0d	0d	100Y	100Y	100Y	100Y	100Y	45R	47R-53Y	96R	75Y	100Y
Sherardized	1.10	0d	0d	<10R	<10R	0d	0d	0d	0d	0	0	0	50Y	0	0d	100Y	100Y	<10R	0
Hot Dip Galvanized	1.61	0	0	46Y	58Y	35Y	50Y	70Y	98Y	0	0	0	0	0	0	0	0	0	0
Electro Galvanized	0.33	100R	100R	100R	100R	100R	100R	100R	100R	0	0	0	slR	50R	58R	80R	80R	53R	63R
Cadmium Plated, Bolt	0.29	100R	100R	100R	100R	100R	100R	100R	100R	67R	92R	97R	100R	15R	32R	65R	95R	97R	100R
Cadmium Plated, Nut	0.10																		
Cadmium Plated, Bolt	0.22	100R	100R	100R	100R	100R	100R	100R	100R	0	<10R	<10R	<10R	100R	100R	100R	100R	0	0
Cadmium Plated, Nut	0.11																		
⅝ BY 2½-IN. BOLTS																			
Sherardized	0.87	0d	0d	0d	0d	0d	0d	0d	0d	0	0	0	0d	0	0	75Y	100Y	10R	<10Y
Sherardized	0.70	0d	0d	0d	0d	0d	0d	0d	0d	100Y	100Y	100Y	100Y	100Y	100Y	100Y	100Y	75Y	100Y
Hot Dip Galvanized	1.40	0	0d	0d	0d	0	0d	23Y	60Y	0	0	0	0	0	0	0	0	0	0
Cadmium Plated	....	100R	100R	100R	100R	100R	100R	100R	100R	0	0	0	0	25R	54R	88R	98R	<10R	0
Cadmium Plated	1.49	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	92R	95R
Electro Galvanized	0.20	100R	100R	100R	100R	100R	100R	100R	100R	<10R	11R	21R	26R	55R	80R	88R	98R	40R	52R

Sherardized	0.84	0d	0d	0d	0d	0d	0d	0d	0d	0	0	0	0d	0	slY	50Y	100Y	slR	slY
Sherardized	0.79	0d	0d	0d	0d	0d	0d	0d	0d	100Y	100Y	100Y	100Y	100Y	100Y	100Y	100Y	75Y	100Y
Hot Dip Galvanized	1.48	0	0d	0d	0d	0	0d	33Y	65Y	0	0	0	0	0	0	0	0	0	0
Electro Galvanized	0.21	100R	100R	100R	100R	100R	100R	100R	100R	0	0	1R	<10R	53R	83R	91R	99R	57R	68R
Electro Galvanized	0.20	100R	100R	100R	100R	100R	100R	100R	100R	0	0	0	0	55R	95R	100R	100R	slR	slY
Cadmium Plated	0.30	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	0	100R

$\frac{3}{8}$ BY $1\frac{1}{2}$-IN. BOLTS

Sherardized	1.20	0d	0d	0d	0d	0	0d	0d	0d	100Y	100Y	100Y	100Y	slY	slY	75Y	100Y	75Y	100Y
Sherardized	0.89	0d	0d	0d	0d	0	0d	0d	0d	0	0	0	0d	0d	0d	100Y	100Y	<10R	slY
Hot Dip Galvanized	1.45	0	0d	0d	0d	0	0d	30Y	62Y	0	0	0	0	0	0	0	0	0	0
Electro Galvanized	0.18	100R	100R	100R	100R	100R	100R	100R	100R	0	0	0	1R	85R	93R	93R	100R	70R	82R
Cadmium Plated	0.14	100R	100R	100R	100R	100R	100R	100R	100R	17R	17R	19R	24R	90R	90R	90R	100R	<10R	slY
Cadmium Plated	0.15	100R	100R	100R	100R	100R	100R	100R	100R	83R	98R	99R	100R	100R	100R	100R	100R	70R	88R

1-IN. ROOFING NAILS

Sherardized	0.90	0d	50R	87R	95R	0d	0d	0d	<10R	100Y	100Y	100Y	100Y	100Y	100Y	100Y	100Y	40Y	50Y
Sherardized	0.86	0d	16R	38R	75R	0d	0d	0d	<10R	100Y	100Y	100Y	100Y	100Y	100Y	100Y	100Y	60Y	90Y
Cadmium Plated	....	100R	100R	100R	100R	100R	100R	100R	100R	0	<10R	<10R	<10R	50R-50Y	100R	100R	100R	20R	50R
Hot Dip Galvanized	1.34	<10Y	57Y	20R-80Y	20R-80Y	58Y	35R-50Y	50R-50Y	65R	0	0	0	0	0	0	0	0	0	0
Hot Dip Galvanized	1.15	<10Y	57Y	20R-80Y	20R-80Y	55Y	35R-50Y	50R-50Y	75R	0	0	0	0	0	0	0	0	0	0
Electro Galvanized	....	100R	100R	100R	100R	100R	100R	100R	100R	35R 25Y	50R	50R	70R	60R	73R	80R	99R	80R	80R
Amaloy	....	26R	50R	50R	60R	0	0	0	<10R	96R	98R	95R	95R	60R-40Y	80R	80R	100R*	80R	100R

NO. 14 BY $2\frac{1}{2}$-IN. WOOD SCREWS

Sherardized	0.94	1R	37R	37R	40R-60Y	1R	<10R	10R	22R	slY	slY	100Y	100Y	100Y	10R	10R	20R	<10R-60Y	<10R-90Y
Sherardized	0.86	1R	18R	15R	20R-80Y	0d	<10R	<10R	22R	slY	slY	100Y	100Y	100Y	100Y	100Y	100Y	30R	Y*
Cadmium Plated	0.07	97R	100R	100R	100R	100R	100R	100R	100R	1R	3R	<10R	<10R	3R	<10R	<10R	60R	slR	0
Hot Dip Galvanized	1.26	10Y	12Y	53Y	60Y	50Y	65Y	80Y	5R-95Y	0	0	0	0	0	0	0	0	0	0
Cadmium Plated	0.04	100R	100R	100R	100R	100R	100R	100R	100R	98R	100R	100R	100R	100R	100R	100R	100R	90R	95R
Hot Dip Galvanized	....	<10Y	10Y	27Y	2R-50Y	37Y	53Y	70Y	5R-95Y	0	0	0	0	0	0	0	0	0	0
Parkerized	....	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R
Electro Galvanized	....	98R	100R	100R	100R	96R	99R	100R	100R	1R	<10R	<10R	<10R	...	...	...	...	40R	45R

KNOCK OUT BOXES

Electro Galvanized	0.21	<10R	<10R	<10R	<10R	16R-15Y	42R	46R	44R	0	0	0	0	0	0	0	0	0	0
Electro Galvanized	0.16	38R	53R	55R	60R	25R	61R	76R	61R	0	0	0d	0d	<10R	<10R	<10R	<10R	<10R	<10R
Hot Dip Galvanized	1.56	0	0	slY	slY	0	0d	13Y	17Y	0	0	0	0	0	0	0	0	0	0
Cadmium Plated	0.12	100R	100R	100R	100R	100R	100R	100R	100R	35R	66R	74R	78R	100R	100R	100R	100R	67R	64R
Cadmium Plated	0.19	100R	100R	100R	100R	100R	100R	100R	100R	25R	32R	33R	33R	54R	70R	78R	81R	<10R	slR
Electric Sherardized	0.28	80R	100R	100R	100R	43R	90R	90R	99R	100nR	100nR	100nR	33R-67nR	40R	73R	78R	83R	95R	100nR
Gas Sherardized	0.19	62R	95R	100R	100R	87R	64R	81R	85R	100R	100R	100R	100R	100Y	67R	67R-33Y	67R-33Y	93R	100R
Electric Sherardized	0.28	0	0	slY	slY	0	0d	0d	slY	0	15Y	28Y	slY	0	0	0	100Y	0d	0
Parkerized	....	36R	37R	100R	70R	15R	27R	43R	25R	70R	79R	87R	91R*	40R	44R	58R	100R	100R	100R
Amaloy	....	<10R	15R	33R	36R	0	0	0	0d	62R	62R	73R	86R*	57R	59R	60R	90R*	50R	25nR
Hot Dip Aluminum	1.84	0d	0d	0d	0d	0	0	0	0d	0	0	0	0	0	0	0	0	slR	0

TABLE VII.—REPORT ON INSPECTIONS OF METALLIC COATINGS, ETC. (*Continued*).

Abbreviations and Symbols Used: 0 - no rust; 5, 10, 25, 100 - approximate percentages; R - rusting of base metal; Y - yellow or orange alloy rust; * - rust spots widely distributed; d - black or dark surface film (soot or dirt); a - in angle; < - less than; e - edges; th - threads; sl - slight; n - near; s - stain.

Coating	Weight, oz. per sq. ft. of surface	Exposure at Brunot Island, Pa.				Exposure at Altoona, Pa.				Exposure at State College, Pa.				Exposure at Sandy Hook, N. J.				Exposure at Key West, Fla.	
		120 Weeks	146 Weeks	173 Weeks	199 Weeks	121 Weeks	147 Weeks	174 Weeks	200 Weeks	120 Weeks	146 Weeks	173 Weeks	199 Weeks	121 Weeks	147 Weeks	174 Weeks	200 Weeks	162 Weeks	206 Weeks
STEEL HINGES																			
Cadmium Plated	0.29	100R	100R	100R	100R	100R	100R	100R	100R	0	<10R	<10R	<10R	52R	69R	86R	96R	10R	<10R
Cadmium Plated	0.32	100R	100R	100R	100R	100R	100R	100R	100R	0	0	0	0	10R	27R	50R	72R	<10R	<10R
Hot Dip Galvanized	1.54	10Y	13Y	45Y	51Y	45Y	58Y	68Y	81Y	0	0	0	0	0	0	0	0	0	0
Electric Sherardized	0.40	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	43Y	65Y
Gas Sherardized	0.68	<10R	17R	32R	40R	0d	<10R	<10R	16R	100Y	100Y	<10R - 95Y	<10R - 98Y	100Y	100Y	100Y	100Y	10R	slY
Parkerized	....	<10R	18R	20R	40R	0d	0d	0d	0d	30R	73R	82R	100R	48R	92R	100R	100R	100R	100R
Electro Galvanized	0.19	100R	100R	100R	100R	100R	100R	100R	100R	0	<10R	15R	19R	70R	80R	87R	90R	100R	100R
BULLDOG CLAMPS																			
Electro Galvanized	3.41	0	<10R	<10R	<10R	0	1R	<10R	<10R	0	0	0	0	0	0	0	0	0	0
Hot Dip Galvanized	1.88	0	0	15Y	20Y	0	<10Y	54Y	75Y	0	0	0	0	0	0	0	0	0	0
Cadmium Plated	0.22	100R	100R	100R	100R	100R	100R	100R	100R	0	<10R	<10R	<10R - 90Y	100R	100R	100R	100R	100R	100R
Cadmium Plated	0.17	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R
Gas Sherardized	0.46	<10R	27R	17R	50R - 50Y	0d	0d	<10R	<10R	0	slY	43Y	75Y	100Y	78R	100R	100R	58Y	90Y
Electric Sherardized	1.25	<10R	29R	42R	25R - 50Y	0d	0d	0d	0d	0	0	0	slY	0	0	100Y	100Y	10Y	slY
Electric Sherardized	0.58	0d	35R	43R	50R	0d	24R	29R	35R	0	0	0	slY	0	slY	slY	100Y	<10R	30Y
Hot Dip Aluminum	1.35	0d	0d	0d	0d	0d	0d	0d	0d	0	0	0	0	0	0	0	0	<10R	slY
Parkerized	....	0	17R	20R	20R	0d	0d	0d	0d	53R	53R	72R	86R*	75R	82R	100R	100R	100R	100R
¼ BY 3-IN. PLAIN STEEL FLATS																			
Electro Galvanized	0.76	36R	62R	90R	93R	54R	86R	95R	99R	0	0	0	0	0	0	0	0	0	0
Electro Galvanized	0.45	0	0	slY	slY	0	<10R	21R	35R	0	0	0	0	0	0	0	0	<10R	<10R
Hot Dip Galvanized	2.49	0	0	0	0	0	0	0	0	0	0	0	0	1R	1R	1R	1R	0	0
Hot Dip Aluminum	0.90	0d	0d	0d	0d	0d	0d	0d	0d	0	0	0	0	0	0	0	0	0	0
Cadmium Plated	0.23	100R	100R	100R	100R	100R	100R	100R	100R	0	0	0	0	<10R	50R	71R	90R	slR	slR
Electric Sherardized	....	0d	100R	100R	100R	70R	100R	100R	100R	100Y	100Y	100Y	100Y	100Y	100Y	1R - 99Y	1R - 99Y	50Y	90Y
Gas Sherardized	0.12	100R	100R	100R	100R	100R	100R	100R	100R	80R	100R	100R	100R	100R	100R	100R	100R	100R	100R
Lead Plated	....	<10R	<10R	23R	24R	0d	<10R	0d	0d	32R	47R	51R	50R	12R*	15R*	19R*	20R*	37R	<10R 20Y

¼ BY 3-IN. COPPER-BEARING STEEL FLATS

Electro Galvanized	0.84	29R	49R	64R	75R	65R	80R	91R	98R	0	0	0	0	0	0	0	0	0	0
Electro Galvanized	0.66	0	0	<10Y	<10R	<10Y	19R	34R	67R	0	0	0	0	1R	1R	<10R	<10R	0	0
Hot Dip Galvanized	2.67	0	0d	0d	0d	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Dip Aluminum	0.66	0d	0d	0d	0d	0d	0d	0d	0d	0	0	0	0	0	0	0	0	0	0
Cadmium Plated	0.27	100R	100R	100R	100R	100R	100R	100R	100R	0	0	0	slR	66R	78R	91R	97R	0d	slR
Electric Sherardized	....	0d	100R	100R	100R	<10R	100R	100R	100R	100Y	100Y	100Y	100Y	100Y	<10R-95Y	<10R-95Y	<10R-98Y	53Y	95Y
Gas Sherardized	0.18	100R	100R	100R	100R	100R	100R	100R	100R	79R	100R	100R	100R	100R	100R	100R	100R	100R	100R
Lead Plated	....	<10R	<10R	10R	29R	0d	<10R	0d	0d	30R	37R	43R	36R*	21R*	26R*	25R*	27R*	27R	10R-10Y

NO. 209 WINDOW FRAME SECTIONS

Electro Galvanized	0.67	68R	83R	92R	96R	84R	88R	91R	96R	0	0	0	0	0	0	0	0	<10R	<10R
Electro Galvanized	0.24	11R	50R	66R	68R	48Y	29R	49R	57R	0	0	0	0	<10R	18R	21R	20R	0	0
Hot Dip Galvanized	3.10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Dip Aluminum	0.61	0d	0d	0d	0d	0d	0d	0d	0d	0	0	0	0	0	0	0	0	0	0
Cadmium Plated	0.24	100R	100R	100R	100R	100R	100R	100R	100R	15R	23R	23R	25R	37R	50R	57R	57R	37R	27R
Electric Sherardized	0.52	0d	88R	93R	100R	0d	64R	69R	77R	67Y	100Y	100Y	100Y	100Y	1R-99Y	<10R-97Y	<10R-97Y	57Y	90Y
Amaloy	....	<10R	<10R	22R	30R	0	0d	0d	0d	43R	52R	68R	64R*	24R*	35R*	26R*	80R*	40R	<10Y

NO. 792 WINDOW FRAME SECTIONS

Electro Galvanized	0.54	60Ra	70R	72R	88R	67Ra	77R	84R	87R	<10R	<10R	<10R	<10R	45Ra	40Ra	40Ra	52R	0	0
Electro Galvanized	0.35	69R	93R	98R	99R	73R	98R	100R	100R	<10R	11Ra	12Ra	13Ra	50Ra	50Ra	53Ra	61R	40Ra	33R
Hot Dip Galvanized	2.60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Dip Aluminum	1.30	0d	0d	0d	0d	0d	0d	0d	0d	0	0	0	0	0	0	0	0	0	0
Cadmium Plated	0.22	100R	100R	100R	100R	100R	100R	100R	100R	0	1R	1R	<10R	38Ra	47Ra	58Ra	57R	<10R	<10R
Cadmium Plated	0.17	100R	100R	100R	100R	100R	100R	100R	100R	33Ra	33Ra	35Ra	40Ra	60Ra	62Ra	70Ra	80R	47R	28R
Electric Sherardized	0.57	<10R	<10R	<10R-95Y	15R-85Y	0d	<10R	<10R	<10R	slY	95Y	100Y	100Y	10R-90Y	20R-80Y	27R-73Y	30R	33Y	25Y
Gas Sherardized	0.58	13R	83R	83R	86R	<10R	48R	52R	66R	100nR	100nR	100nR	100nR	<10R	<10R-95Y	100Y	100Y	72Y	<10R-85Y
Parkerized	....	100R	100R	100R	100R	25R	67R	82R	84R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R

NO. 161 WINDOW FRAME SECTIONS

Electro Galvanized	0.89	80R	65R	88R	88R	73Ra	74R	75R	83R	<10Ra	<10Ra	<10Ra	<10Ra	<10Ra	18Ra	27Ra	34R	0	0d
Electro Galvanized	0.81	68R	83R	85R	88R	66Ra	64R	87R	82R	0	0	0	0	<10Ra	15Ra	17Ra	18R	<10R	<10R
Hot Dip Galvanized	2.97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Dip Aluminum	0.66	0	0d	0d	0d	0d	0d	0d	0d	0	0	0	0	0	0	0	0	<10R	slY
Cadmium Plated	0.22	100R	100R	100R	100R	100R	100R	100R	100R	22Ra	28Ra	33Ra	35Ra	39R	60R	63R	72R	<10R	<10R
Cadmium Plated	0.15	100R	100R	100R	100R	100R	100R	100R	100R	60R	62R	71R	62R	91R	96R	98R	100R	80R	63R
Electric Sherardized	0.32	<10Y	<10R	<10R-15Y	<10R	0d	<10R	<10R	<10R	slY	slY	slY	86Y	slY	48Y	70Y	100Y	40R	20Y
Gas Sherardized	0.42	0d	18R	18R	45R	<10R	25R	33R	36R	100Y	100Y	1R-99Y	1R-99Y	100Y	1R-99Y	1R-99Y	1R-99Y	75Y	95Y
Parkerized	....	100R	100R	100R	100R	23R	51R	64R	52R	100R	100R	100R	100R	100R	100R	100R	100R	100R	100R

ments have been prepared to summarize the facts on hardware, structural shapes, tubular goods, etc.

1. The resistance to corrosion of these zinc coatings depends substantially on the weight of coating and not on the process by which these coatings were applied.

2. Electrodeposited coatings (whether of zinc or cadmium) are thinner in the recessed parts than they are on regular sections and non-recessed areas. Consequently, these coatings fail first in the recessed portions of the test specimen.

3. Hot-dipped aluminum coatings (which are usually heavy coatings) have given good protection at all locations. These coatings on the samples under test are distinctly rough and it was necessary to recut the threads on the aluminum-coated nipples and ells in order to get them together.

4. At Key West, Sandy Hook, and State College it is evident that lead coatings do not prevent rusting of the base metal which is exposed at pinholes, as well as do zinc and cadmium coatings. At industrial locations, such as Altoona and Brunot Island, where zinc and cadmium themselves are rapidly weathered away, the lead is sufficiently resistant of itself to offer considerable protection to the underlying iron or steel.

5. At no location have Parkerized and oiled finishes been found to afford suitable protection for outdoor service. This committee has not tested articles which have been Parkerized and subsequently painted or enameled.

This subcommittee has in no instance to date tested coated articles which have been given supplementary coatings.

ELECTRODEPOSITED COATINGS

Detailed reports covering exposure tests on electrodeposited coatings on steel have appeared from time to time in the *Review of the American Electroplaters' Society*. Anyone particularly interested in the plating conditions used in this investigation will find the information they desire in the publications of the American Electroplaters' Society, or can obtain this information directly from Mr. William Blum, at the U. S. Bureau of Standards, who is in charge of this work.

The exposure tests of electroplated coatings on steel have been in progress at Pittsburgh (Brunot Island), Pa., Sandy Hook, N. J., State College, Pa., Key West, Fla., New York City, and Washington, D. C., for nearly a year. Inspections have been made at intervals of approximately one month by members of the Joint Inspection Committee and other interested persons. This report is confined to the conclusions reached from an examination of the specimens finished with nickel and chromium, since there have been insufficient failures of the cadmium and zinc coatings to warrant any statement at the present time.

The following tentative conclusions are based principally on the results of the inspections at Key West and Sandy Hook, although they are approximately true at Washington and State College where the failure was less rapid; and, at Pittsburgh and New York where discoloration of the surface rendered the ratings less certain:

1. *Thickness.*—The protective value is determined principally by the total thickness of the nickel or of nickel and copper. Coatings with a total thickness of less than 0.0005 in. have little protective value, while those with 0.002 in. are nearly perfect.

2. *Effect of Copper.*—The presence of a copper layer reduces the protective value of a coating having a given total thickness.

3. *Effect of Chromium.*—Very thin chromium coatings reduce the protective value of relatively thin deposits of nickel or of copper plus nickel, while thicker coatings of chromium furnish added protection.

4. *Effect of Nickel.*—A sufficiently heavy coating of nickel will minimize the effect of a copper layer next to the steel if the final chromium finish is approximately 0.00003 in. or more in thickness.

Additional sets of specimens have been prepared and exposed in the four most severe locations to confirm and extend the above indications.

PROPOSED FIELD TEST ON ZINC-COATED WIRE

A special committee under the chairmanship of Mr. W. H. Finkeldey has corresponded with communication and transportation companies, farm organizations and agricultural bureaus. This correspondence indicated that there exists a definite desire on the part of consumers for the information which tests on wire might develop.

The subcommittee voted at its meeting, held in New York City, March 7, 1933, that tests on zinc-coated wire should be started. The proposed tests will include various weights of zinc coating on wire exposed at a number of test locations.

This report of Subcommittee VIII has been submitted to letter ballot of the subcommittee which consists of 39 members; 34 members returned their ballots, of whom 28 have voted affirmatively and 4 negatively.

Respectfully submitted on behalf of the subcommittee,

R. F. PASSANO,
Chairman.

REPORT OF SUBCOMMITTEE X ON EMBRITTLEMENT INVESTIGATION

The Sectional Committee on Specifications for Zinc Coating of Iron and Steel has adopted the recommendations of Subcommittee X, proposed in 1932, for the revision of the Standard Specifications for Zinc (Hot-Galvanized) Coatings on Structural Steel Shapes, Plates and Bars and Their Products (A 123 – 30).[1] The recommended revisions which were published in last year's report[2] will be submitted to the Society at this annual meeting and if adopted by the Society will be incorporated in the Standard Specifications A 123. The recommendation that these specifications be adopted as an American Standard was also approved by the Sectional Committee and will be submitted to the American Standards Association at an early date.

The work of the subcommittee during the past year concerned the questions propounded at the 1932 annual meeting and which were incorporated in the 1932 report.[2] These questions concern the Tentative Recommended Practice for Safeguarding Against Embrittlement of Hot-Galvanized Structural Steel Products and Procedure for Detecting Embrittlement (A 143 – 32 T).[3] It will be recalled that the Recommended Practice was not offered to the Sectional Committee for consideration for approval by the A.S.A. It was the belief that it should have only A.S.T.M. status, at least for the present or until it received the test of practicability through use in practice. A year or two is required for ascertaining the practicability of the Recommended Practice before unconditionally encumbering the trade with the testing program. In the light of the committee's disclosures, normal improvements over a period of a few years in the industries involved may cause the Recommended Practice, or certain parts thereof, to become obsolescent, for, after all, it is based on the present practices in galvanizing, fabricating and manufacturing.

The questions involved in substance are queries as to:

(*a*) The completeness of the evidence on which was founded the recommendation that shapes $\frac{3}{4}$ in. and over should be drilled or subpunched and reamed;

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 284.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, pp. 124, 125 (1932).

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 615 (1932); also 1932 Book of A.S.T.M. Tentative Standards, p. 162.

(*b*) Whether the committee is justified in branding by inference all steels other than open-hearth bridge steel (A.S.T.M. Standard Specifications A 7)[1] as unsuitable for galvanizing after fabrication;

(*c*) The need for reducing the gage length from 2 in. to 1 in. for testing fabricated shapes in the intermediate and small sections;

(*d*) Whether the requirements for 5 per cent elongation in the angle bend test is too severe for actual practice; and

(*e*) A simple, practical and economic acceptance test for guarding against injurious embrittlement of formed structural steel hardware, such as shaped plate hangers, U-bolts, step-bolts, racks and like products.

These queries were contingent upon the subcommittee continuing a sensible, organized and watchful effort to settle these questions. Under the conditions now prevalent it was considered utterly impossible to continue an expensive program of testing in an institutional or a commercial laboratory. It was the belief that all essential data and information to answer the queries and to revise the Tentative Recommended Practice (A 143 – 32 T) could be procured by collecting the test results and experience data from the consumers and fabricators. Accordingly two small committees were appointed to collect data.

Mr. A. B. Campbell, with the assistance of Messrs. J. R. Brossman and H. O. Hill, was delegated and accepted responsibility for circularizing the industry with a form, approved by the Steering Committee, for collecting data on testing which would enable the Steering Committee to make needed recommendations covering the points mentioned in Paragraphs (*a*) to (*d*) above. The form provides for reporting the following data:

- Specimen Number
- Date of Tests
- Test Specimen
- Angle Size
- Diameter of Punched Hole
- Edge Distance
- Edge Material
- Ultimate Load in Pounds
- Temperature
- Test Measurements and Data:
  - Elongation in 2 in.
  - Elongation in 1 in.
- Micrometer Measurements in Inches, Both Before Testing and After Testing
- Reduction in Thickness
- Appearance of Fracture, Silky or Granular

Anyone having experience here or abroad with embrittlement in the structural or any allied ferrous metal field is urged to advise the committee.

Mr. W. G. Kelley, assisted by Messrs. H. W. Gillett and C. W. Kenney, was appointed to circularize the industry for actual tests now in use, and for recommendations to satisfy the demand for an acceptance test for so-called galvanized hardware made from rolled or structural steel products, Paragraph (*e*), above.

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[1] Standard Specifications for Structural Steel for Bridges (A.S.T.M. Designation: A 7 – 29), 1930 Book of A.S.T.M. Standards, Part I, p. 67.

Both of these committees are actively engaged in collecting data, but are unable to report findings during the present year. It is hoped that they will have definite progress data for the consideration of the Steering Committee (Messrs. J. J. Shuman, chairman, C. F. W. Rys, H. O. Hill and W. G. Kelley) during 1934. As was expected, these committees are unable to function 100 per cent during the abnormally depressed state of industry and commerce.

The funds collected and the disposition thereof from the beginning of the investigation to March 31, 1933, follows:

Receipts:		
Contributions	$18 423.00	
Interest	230.93	
Total Receipts		$18 653.93
Disbursements:		
Battelle Memorial Institute	17 402.13	
A.S.T.M. reprints of report	993.00	
Miscellaneous	130.56	
Total Disbursements		18 525.69
Cash Balance, March 31, 1933		128.24

The chairman must relinquish all connections with Subcommittee X as of the date of this report and wishes to thank each member, and particularly the Steering Committee, for the wholehearted and faithful service rendered to the Society in conducting this investigation. The success accomplished in arriving at an understanding of this, at one time, highly controversial subject, is due particularly to the untiring efforts of Messrs. J. J. Shuman, C. F. W. Rys, J. O. Leech, H. O. Hill and W. G. Kelley. To Messrs. H. W. Gillett, J. H. Gibboney and C. L. Warwick the committee owes a debt of gratitude for technical assistance and executive encouragement. The outstanding character of the work of Subcommittee X is confirmed by the announcement of the award of the Charles B. Dudley Medal for 1933 to Mr. Samuel Epstein for the paper in which was reported the results of the embrittlement investigation.[1] Mr. Epstein headed the group of scientists at Battelle Memorial Institute engaged in carrying on the technical work.

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[1] Samuel Epstein, "Embrittlement of Hot-Galvanized Structural Steel," *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part II, p. 293 (1932).

This report has been submitted to letter ballot of the subcommittee which consists of 33 members; 28 members returned their ballots, of whom 27 have voted affirmatively and none negatively.

Respectfully submitted on behalf of the subcommittee,

V. F. HAMMEL,
Chairman.

C. S. TREWIN,
Secretary.

REPORT OF SECTIONAL COMMITTEE

ON

ZINC COATING OF IRON AND STEEL

The only meeting of the Sectional Committee on Zinc Coating of Iron and Steel held during the year was on March 8, 1933, at New York City during the spring group committee meetings of the American Society for Testing Materials.

Technical Committee I on Hardware and Fastenings (A. L. Fox, chairman).—Technical Committee I completed the Specifications for Zinc Coating (Hot-Dip) on Hardware and Fastenings which were submitted to the sectional committee for letter ballot previous to their consideration at the March meeting. Inasmuch as these specifications were not approved by the 90 per cent vote required on this initial letter ballot, they were considered at the meeting of the sectional committee held in New York City on March 8, at which time, following certain modifications, they were accepted by the sectional committee. The specifications as modified were submitted to the sectional committee for confirmation by letter ballot. This letter ballot vote of the sectional committee, which consists of 45 members, has resulted as follows: 42 members returned their ballots, of whom 34 have voted affirmatively, 5 negatively and 3 members marked their ballots not voting.

Subject to approval by letter ballot of the sectional committee, the proposed Specifications for Zinc Coating (Hot-Dip) on Hardware and Fastenings, appended hereto,[1] are herewith submitted to the sponsor, the American Society for Testing Materials, for publication as tentative.

Technical Committee III on Zinc (Hot-Galvanized) Coatings on Structural Steel Shapes, Plates and Bars and Their Products (V. F. Hammel, chairman).—This technical committee has approved by unanimous letter ballot, the recommendations of Subcommittee X, of Committee A-5, on Embrittlement Investigation,[2] and has reported to the sectional committee as follows:

1. That the recommendations for the revision of the Standard Specifications for Zinc (Hot-Galvanized) Coatings on Structural Steel Shapes, Plates and Bars and Their Products (A.S.T.M. Designation:

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[1] See p. 583.—Ed.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 124 (1932).

A 123 – 30) of the American Society for Testing Materials,[1] as recommended by Subcommittee X of the A.S.T.M. Committee A-5 in its 1932 report[2] be approved.

2. That the specifications with the above modifications be reported to the sectional committee with the recommendation that they be advanced from American Tentative Standard to the status of American Standard.

3. That, provided the above recommendations are accepted by the sectional committee, the Technical Committee III, having completed its work, be discharged.

The report of this technical committee was submitted to the sectional committee for letter ballot under date of February 14, 1933. The letter ballot vote of the sectional committee, which consists of 46 members, has resulted as follows: 44 members returned their ballots, of whom 43 have voted affirmatively, 0 negatively and 1 member marked his ballot not voting.

The sectional committee at its meeting in New York on March 8, 1933, reviewed the results of this ballot and the report of this technical committee was declared approved.

The sectional committee therefore recommends that the Standard Specifications for Zinc (Hot-Galvanized) Coatings on Structural Steel Shapes, Plates and Bars and Their Products (A.S.T.M. Designation: A 123 – 30),[1] revised as recommended by Subcommittee X of Committee A-5,[2] be approved by the American Society for Testing Materials and offered to the American Standards Association for approval as American Standard.

Technical Committee IV on Pipes and Their Fittings (C. J. Krieger, chairman).—No report was made by Technical Committee IV at the meeting of the sectional committee on March 8, but attention was called to the status of the Tentative Specifications for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Ordinary Uses (A.S.T.M. Designation: A 120 – 32 T) of the American Society for Testing Materials.[3] It was pointed out that these specifications had been considered by the sectional committee by letter ballot action in the latter part of 1931. At a meeting of the sectional committee held in Cleveland in March, 1932, consideration was given to the negative votes cast in this letter ballot and the question of meeting the points raised by those casting negative ballots was referred to a special subcommittee representing the sectional committee, the A.S.T.M. Committee A-5 on Corrosion of Iron and

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 284.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 125 (1932).

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 556 (1932); also 1932 Book of A.S.T.M. Tentative Standards, p. 105.

Steel, and the A.S.T.M. Committee A-1 on Steel. So far this subcommittee has made no report. In February, 1933, a preliminary report on piping standards was distributed by the Sectional Committee on Standardization of Dimensions and Material of Wrought-Iron and Wrought-Steel Pipe and Tubing. Later advice from the secretary of this sectional committee on pipe indicated that the Specifications A 120 had been deferred pending further study of certain technical details, thus avoiding the possibility of conflicting recommendations from two sectional committees.

Technical Committee VII on Methods of Testing (E. S. Taylerson, chairman).—The research group of Technical Committee VII has under consideration further experimental results from one of the cooperating laboratories on the subject of industrial atmosphere tests. Another group is presenting as a part of the report of Committee A-5[1] a revision of the Standard Methods of Determining Weight of Coating on Zinc-Coated Articles (A.S.T.M. Designation: A 90) based on considerable experimental work on stripping methods. The committee is asking Committee A-5 to submit these revised methods[2] to the Society for immediate approval as standard. The Preece test group has developed further research information which will need to be considered in the revision and interpretation of this test, but a report has not yet been prepared.

This report has been submitted to letter ballot of the sectional committee, which consists of 45 members; 42 members returned their ballots, of whom 39 have voted affirmatively and 2 negatively.

Respectfully submitted on behalf of the sectional committee,

J. A. CAPP,
Chairman.

A. B. CAMPBELL,
Secretary.

EDITORIAL NOTE

The proposed Tentative Specifications for Zinc Coating (Hot-Dip) on Hardware and Fastenings were accepted for publication as tentative and appear on page 583.

Revisions proposed for immediate adoption in the Standard Specifications for Zinc (Hot-Galvanized) Coatings on Structural Steel Shapes, Plates and Bars and Their Products were approved at the annual meeting by a unanimous vote and were subsequently adopted by letter ballot of the Society on September 1, 1933. The specifications in their revised form appear in the 1933 Book of A.S.T.M. Standards, Part I, page 309.

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[1] See p. 141.—ED.

[2] The revised methods appear in the 1933 Book of A.S.T.M. Standards, Part I, p. 317.—ED.

REPORT OF COMMITTEE A-6
ON
MAGNETIC PROPERTIES

Due to limitations in traveling budgets, it has been impossible to hold a meeting of Committee A-6 on Magnetic Properties or any of its subcommittees since last June. However, a limited amount of work has been carried on by correspondence.

The completely revised Methods of Test for Magnetic Properties of Iron and Steel (A 34 – 32 T) have been under scrutiny for a year and only a few minor suggestions for change have been received. These methods were submitted to the Electrophysics and Research Committees of the American Institute of Electrical Engineers for comment. Suggested changes were received from only one member, and these are being given careful consideration.

ACTIVITIES OF SUBCOMMITTEES

Subcommittee I on Definitions and Nomenclature (W. J. Shackelton, chairman).—Some months ago, a Sectional Committee functioning under the American Standards Association published their proposed definitions of electrical terms, including magnetic terms and definitions. The definitions in the section on magnetic terms were largely the contributions of the representatives of the American Society for Testing Materials on the Sectional Committee and it is believed include quite generally the ideas of Committee A-6. There are, however, a few points of disagreement, and it is believed that the Tentative Definitions of Terms, with Units and Symbols, Relating to Magnetic Testing (A 127 – 31 T) should be continued as tentative until these points of difference can be settled and until the Sectional Committee definitions are adopted.

Subcommittee II on Alternating Current Tests at Low Inductions (R. L. Sanford, chairman).—Very little further experimental work has been done on the low induction testing methods. It is believed that the procedure as described in the Tentative Methods of Test for Magnetic Properties of Iron and Steel (A 34 – 32 T) will be satisfactory with possibly one or two simplifications.

Subcommittee III on Tests at High Magnetizing Forces (L. E. Howard, chairman).—A new apparatus for high magnetizing force testing has been developed this year at the U. S. Bureau of Standards.[1] This should be a valuable addition to the already approved methods.

RECOMMENDATIONS AFFECTING STANDARDS

The committee recommends that the tentative revision of the Standard Methods of Test for Magnetic Properties of Iron and Steel (A 34 – 28)[2], proposed last year in the form of separate tentative methods[3] be referred to letter ballot of the Society for adoption to supersede the present standard methods. This recommendation has been referred to letter ballot of the committee, which consists of 16 members; 9 members returned their ballots, all of whom have voted affirmatively.

This report has been submitted to letter ballot of the committee which consists of 16 members; 9 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

THOMAS SPOONER,
Chairman.

R. L. SANFORD,
Secretary.

EDITORIAL NOTE

The tentative revision of the Standard Methods of Test for Magnetic Properties of Iron and Steel in the form of separate tentative methods, with modifications proposed on the floor of the annual meeting, see Summary of Proceedings, page 9, was approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1933. The revised methods which supersede the existing standard methods appear in the 1933 Book of A.S.T.M. Standards, Part I, page 396.

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[1] R. L. Sanford and E. C. Bennett, "An Apparatus for Magnetic Testing at High Magnetizing Forces," U. S. Bureau of Standards *Journal of Research*, p. 567, April, 1933.

[2] 1930 Book of A.S.T.M. Standards, Part I, p. 396.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 650 (1932); also 1932 Book of A.S.T.M. Tentative Standards, p. 206.

REPORT OF COMMITTEE A-7
ON
MALLEABLE IRON CASTINGS

Committee A-7 on Malleable Iron Castings has held no meeting during the year 1932.

The Subcommittees on Corrosion Resisting Properties of Malleable Iron and on Specifications for Malleable Castings for Flanges, Pipe Fittings and Valve Parts have no reports to make at this time. The work of these subcommittees is, however, being continued.

The committee recommends that the tentative revision of the Standard Specifications for Malleable Castings (A 47 – 30),[1] proposed last year in the form of separate tentative specifications entitled Tentative Specifications for Malleable Iron Castings (A 47 – 32 T),[2] be referred to letter ballot of the Society for adoption to supersede the present standard specifications. This recommendation has been referred to letter ballot of the committee which consists of 38 members; 30 members have returned their ballots, of whom 28 have voted affirmatively, 0 negatively and 2 members marked their ballots not voting.

This report has been submitted to letter ballot of the committee which consists of 38 members; 31 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

W. P. PUTNAM,
Chairman.

ENRIQUE TOUCEDA,
Secretary.

EDITORIAL NOTE

The tentative revision of the Standard Specifications for Malleable Castings, in the form of separate tentative specifications to supersede the present standard, was approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1933. The standard specifications appear in the 1933 Book of A.S.T.M. Standards, Part I, page 490.

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 491.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 633 (1932); also 1932 Book of A.S.T.M. Tentative Standards, p. 187.

REPORT OF COMMITTEE A-10
ON
IRON-CHROMIUM, IRON-CHROMIUM-NICKEL AND RELATED ALLOYS

Committee A-10 has held no meeting during the year, the last meeting having been held during the 1932 annual meeting of the Society. A meeting of the Advisory Committee was held in New York City, on March 8, 1933, while subcommittees have met infrequently, relying largely on correspondence for conducting their work. A few changes in personnel have taken place, resulting in a present membership of 55: of whom 23 are classed as producers, 22 as consumers and 10 as general interest members.

ACTIVITIES OF SUBCOMMITTEES

Subcommittee I on Classification of Data (T. H. Nelson, chairman).—This subcommittee has listed the various chemical, physical, mechanical and fabricating properties that are of importance in connection with the manufacture and application of alloys within its jurisdiction, and is now constructing a form for the presentation of these data along with information on successful spheres of application, marketed forms, etc., this form to permit compact assembly of the data for each alloy type on the two pages of a single printed sheet. It is further assembling, in its initial efforts, strictly representative data and information on the following alloys, regarded as belonging to the plain iron-chromium group:

4 to 6 per cent chromium
9 to 11 per cent chromium with silicon
12 to 14 per cent chromium with 0.12 per cent maximum carbon
12 to 14 per cent chromium with 0.40 per cent maximum carbon
16 to 18 per cent chromium with 0.12 per cent maximum carbon
16 to 18 per cent chromium with 0.70 per cent maximum carbon
20 to 30 per cent chromium

Subsequently, attention will be devoted to the following three additional groups: iron-nickel alloys, iron-chromium-nickel alloys with chromium in greater percentage than nickel, and iron-chromium-nickel alloys with nickel in greater percentage than chromium. A scheme of numerical designation has been established that will be used in connection with these data sheets and likewise used in specifications.

Subcommittee III on Methods of Chemical Analysis (F. B. Foley, chairman).—Subcommittee III is continuing to assemble and collect for study methods of analysis of the high-chromium-nickel-iron alloys for the purpose of developing a recommended procedure.

Subcommittee IV on Methods of Corrosion Testing (W. R. Huey, chairman).—The laboratory corrosion studies of four corrosion-resistant alloys, using several methods of examination, have been completed, the summary of this work is presented in the report appended hereto. Additional problems for this subcommittee to undertake are to be discussed at the June meeting.

Subcommittee VI on Metallography (C. E. MacQuigg, chairman).—There is now in the final stage of preparation a report covering in detail the suggested practice for the polishing and etching of iron-chromium, and iron-chromium-nickel steels for their metallographic examination, which should be ready for presentation to Committee A-10 at the approaching meeting in Chicago.

Subcommittee VII on Welding (F. B. Olcott, chairman).—This subcommittee has prepared what may be described as a recommended practice for the examination and inspection of welds in iron-chromium and iron-chromium-nickel alloys, which will be presented to the committee for discussion at its meeting during the annual meeting in June.

Subcommittee VIII on Specifications (N. L. Mochel, chairman).—Two new sections of this subcommittee have been formed: one, under the guidance of Mr. F. B. Foley, to prepare specifications for castings; and the other, directed by Mr. C. C. Snyder, to draw up specifications for sheets. Each of these specifications is to include all of the commercially important alloy types generally available in their respective forms.

This report has been submitted to letter ballot of the committee, which consists of 55 members; 24 members returned their ballots, of whom 23 have voted affirmatively and 1 negatively.

Respectfully submitted on behalf of the committee,

JEROME STRAUSS,
Chairman.

H. D. NEWELL,
Secretary.

REPORT OF SUBCOMMITTEE IV ON METHODS OF CORROSION TESTING

The testing of materials by exposure to corrosive conditions, either natural or artificial, may be conducted for two purposes. These purposes are remotely related, but a better concept of the general subject is possible if they are considered as separate and distinct.

A corrosion test may be used as a part of the technique employed in making a selection of material for equipment which is required to withstand corrosive service conditions. For this purpose, any single corrosion test, or several different corrosion tests, may be used. A severe test may be employed for material to be used under mildly corrosive conditions, or *vice versa*, depending upon the method of measuring the corrosion effects; for the purpose of material selection, the test must obviously bear some relation to service but to obtain information within a reasonable time limit, some service conditions must be intensified or otherwise altered. However, the test will fail to indicate the choice of the most suitable material unless it is assumed in the beginning that the test conditions can seldom simulate the service faithfully, and unless the test results are intelligently interpreted in the light of full knowledge not only of service conditions but also of test conditions and of the physical and mechanical properties of the material. The test may be complex or simple, may be conducted in the laboratory or in the field, and the data obtained may be expressed in terms of any arbitrary unit; but the success of the test depends entirely upon intelligent interpretation of results. Details of procedure are secondary to interpretation of the test data.

The second purpose of testing materials by corrosion is to determine whether the material conforms to a previously established standard of quality as measured by corrosion resistance. For this purpose, the testing procedure must be devised to produce accurate, readily reproducible data upon every occasion that the test is used. In contrast with the test for the selection of material for a specific purpose, the procedure is of paramount importance in this case and it should be simplified to the point where the variable factors are eliminated, or reduced to a minimum, so that it is conducive to reproducible accuracy of data. The interpretation of the data is not nearly so important as in the case of a test intended for giving information on which is based the selection of material for a particular service.

In order to define more clearly the distinct and separate purposes of these two types of corrosion test, there follows a brief description of the suggested manner of use. The selection type of test may be applied to a number of different materials, which show promise of being suitable for the service under consideration. Before final selection is made, a series of different tests may be necessary to establish not only corrosion resistance but also other characteristics, such for example as physical, mechanical and fabricating properties. Following this stage of the general testing procedure, further elimination of unsuitable material may be accomplished by actual use of small scale equipment under the conditions of service. When the choice has been made, samples of the material to be used in the full scale equipment should be subjected to the type of test mentioned secondly, which may be called the inspection test; its purpose is to insure uniformity and also conformity to the quality of the samples originally approved.

It is important to note at this point that a much wider latitude in the choice of the testing medium is permissible than in the case of the test for material selection. The test should be based upon: first, the general nature of the material inspected (that is, common steel, high-chromium steel, copper-base alloys, etc.); second, the irregularities from lot to lot of manufactured product that may produce irregular service performance and are therefore to be detected; third, the nature of the service to be performed. However, the medium of the test need not be the medium of service, provided they both react similarly in the detection of these differences between lots of material. As a specific example, nitric acid may serve for high-chromium steels used under any oxidizing conditions but may not necessarily be useful for the material of equipment for handling certain solutions containing reducing acids. If the data obtained are accurately reproducible, a standard of quality can be established for the particular material being tested. After this standard has been determined for the material selected by the first mentioned type of test, the degree of adherence to this standard may readily be established for all such material purchased subsequently. With intelligent interpretation, a similar degree of confidence may be placed in a properly planned corrosion test for determining the quality of materials as in a hardness or tension test.

Further discussion of the general subject is not within the scope of this report. Two committees of this Society, Committee A-5 on Corrosion of Iron and Steel and Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys, have conducted extensive investigations concerned chiefly with the corrosion of materials exposed to laboratory and service conditions. Critical discussion of various types of corrosion test and data obtained from exposure tests are presented in the current reports[1] and the reports of these two committees and their respective subcommittees for 1931[2] and 1932[2] and previous years. Much work has been done by others, and the literature on corrosion and corrosion testing is most voluminous.

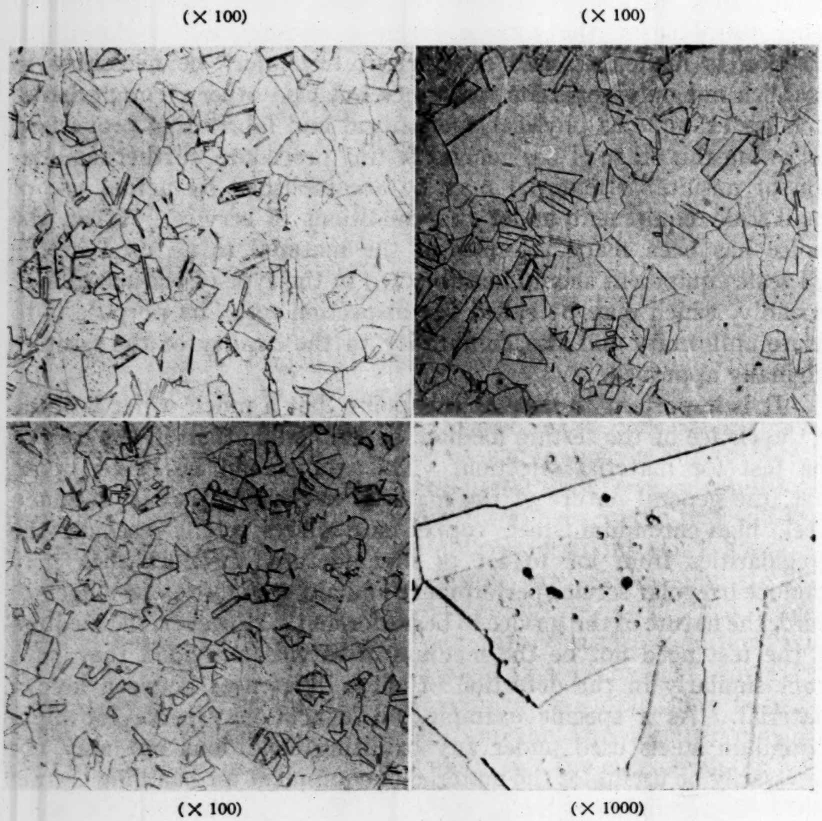

FIG. 1.—Photomicrographs of Alloy A, Transverse Glyceregia Etch.

Material Annealed at 2000 F. (1095 C.), Quenched in Water.

Chemical Analysis, per cent:

Copper	0.09	Silicon	0.54
Manganese	0.40	Nickel	9.15
Phosphorus	0.015	Chromium	17.5
Sulfur	0.013		

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[1] See pp. 140 and 232.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, pp. 171, 252 (1931); Vol. 32, Part I, pp. 100, 201 (1932).

COLLABORATIVE TESTING PROGRAM

At the beginning of experimental work undertaken by Subcommittee IV of Committee A-10, it was decided to restrict the scope of activity to the development of a corrosion test or tests for *inspection* of iron-chromium, iron-chromium-nickel, and related alloys. The first phase of this work has been completed and is reported herewith.

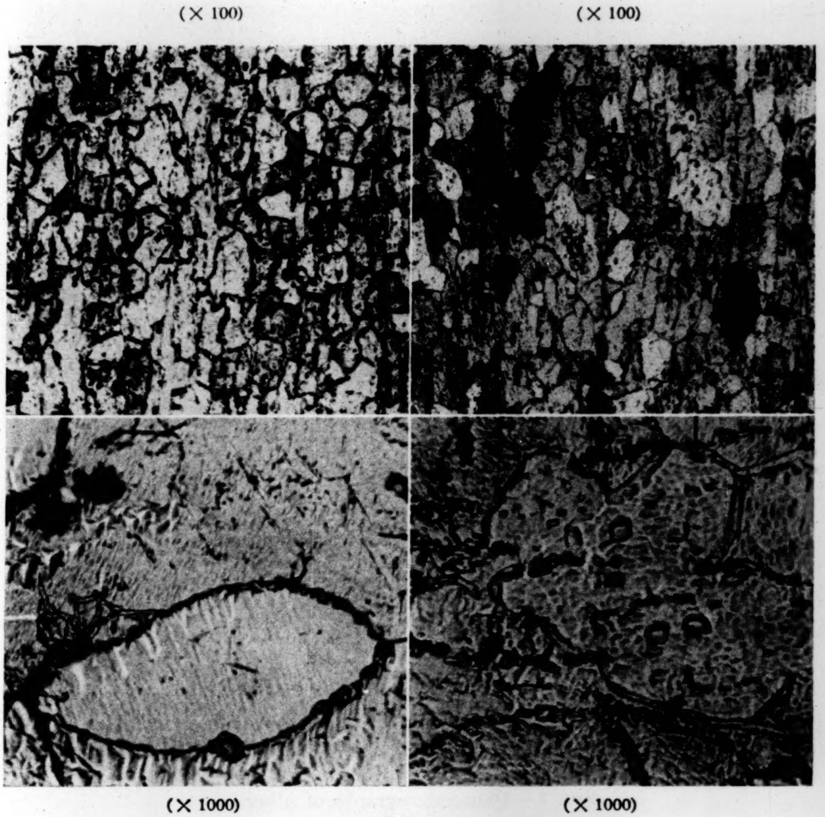


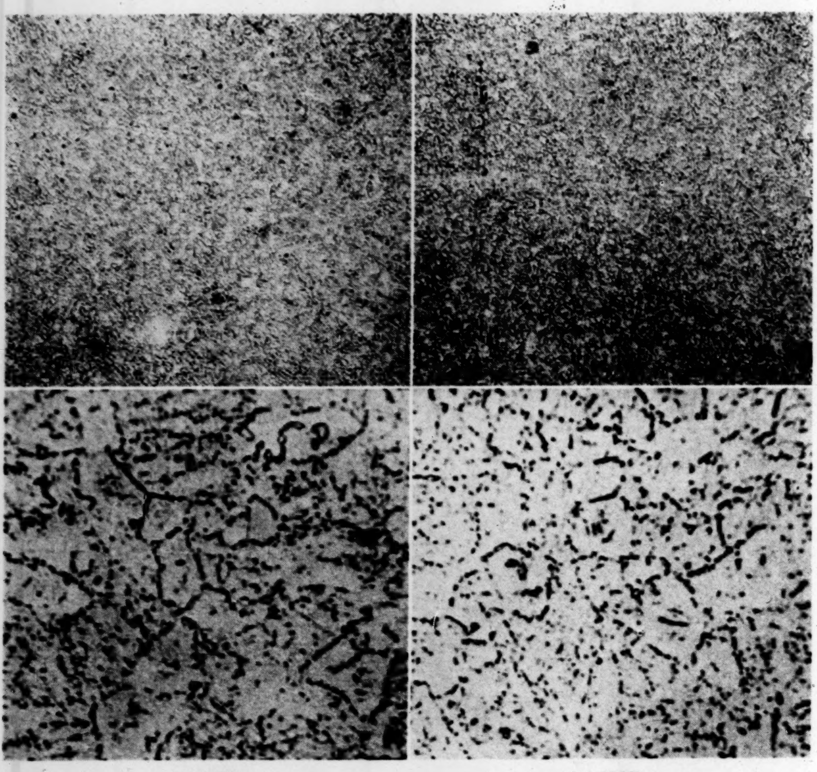
FIG. 2.—Photomicrographs of Alloy B.

Material Annealed at 1450 F. (790 C.), Cooled in Furnace.

Chemical Analysis, per cent:

Carbon	0.09	Silicon	0.34
Manganese	0.37	Nickel	0.10
Phosphorus	0.010	Chromium	17.3
Sulfur	0.012		

The purpose of the testing program was to determine the extent of agreement in data obtained by several laboratories following carefully prescribed test procedures. Accordingly, samples of three commercially important alloys were supplied to fifteen industrial and institutional laboratories for test by three different methods of corrosion testing. The test methods chosen are of interest to different classes of alloy steel users.


(× 100) (× 100)

(× 1000) (× 1000)

FIG. 3.—Photomicrographs of Alloy C.

Material Annealed at 1300 F. (705 C.), Cooled in Furnace.

Chemical Analysis, per cent:

Carbon	0.12	Silicon	0.32
Manganese	0.45	Nickel	0.10
Phosphorus	0.016	Chromium	13.0
Sulfur	0.013		

Alloys Tested:

The samples supplied to the collaborating laboratories were cut from 1-in. diameter bars made by companies represented on the subcommittee. Before cutting the short lengths required for preparing the test specimens, a piece 6 in. in length was cut from each end of each bar and discarded. Each short length was stamped with an identifying letter and numbers before shipment to the testing laboratory, and each test specimen cut therefrom was likewise stamped by the laboratory. For example, A-10-4 designates Alloy A, laboratory No. 10, and specimen No. 4. Test specimens were prepared by the participating laboratories.

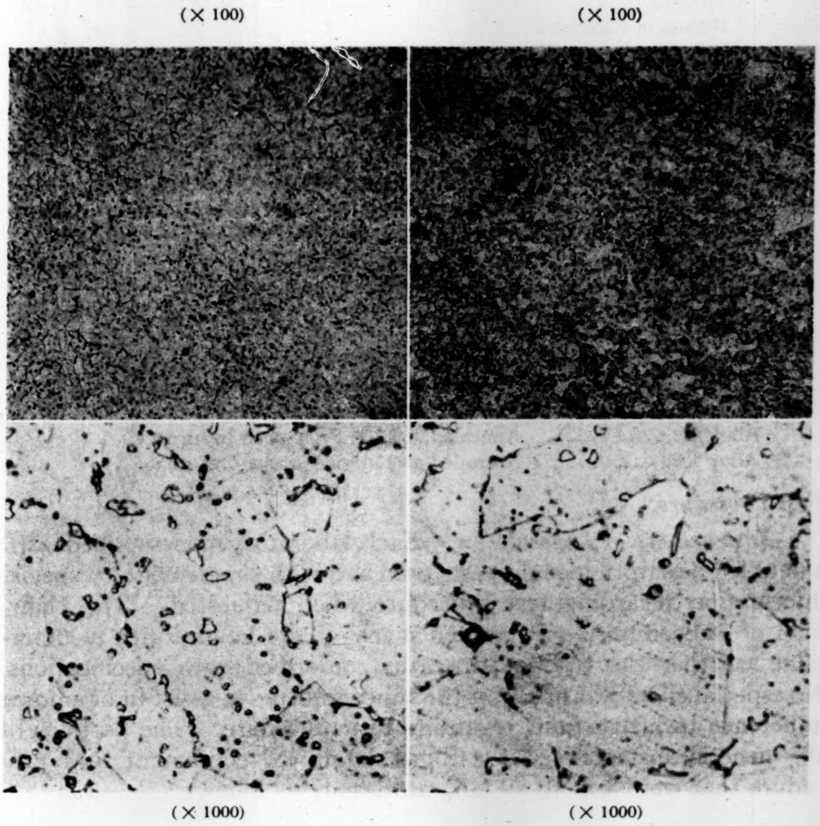


FIG. 4.—Photomicrographs of Alloy D.

Material Annealed at 1700 F. (925 C.), Cooled in Furnace.

Chemical Analysis, per cent:

Carbon	0.12	Silicon	0.32
Manganese	0.45	Nickel	0.10
Phosphorus	0.016	Chromium	13.0
Sulfur	0.013		

Representative photomicrographs of the alloys are shown in Figs. 1 to 4. Chemical analysis was made by the U. S. Bureau of Standards, the manufacturers and a third laboratory.

The chemical composition and heat treatment of the alloys are as follows:

		Chemical Composition, per cent						
	Analyst	Carbon	Manganese	Phosphorus	Sulfur	Silicon	Nickel	Chromium
Alloy A	Manufacturer	0.08	0.38	0.019	0.013	0.50	8.96	17.50
	Bureau of Standards	0.09	....	.....	.....	....	9.24	17.5
	Referee	0.095	0.41	0.010	0.012	0.57	9.09	17.41
Alloy B	Manufacturer	0.12	0.39	.....	.....	....	0.09	18.04
	Bureau of Standards	0.09	....	.....	.....	....	....	17.3
	Referee	0.07	0.36	0.010	0.012	0.34	0.11	17.29
Alloy C	Manufacturer	0.10	0.45	0.016	0.013	0.32	0.10	12.98
	Bureau of Standards	0.12	....	.....	.....	....	....	13.1
	Referee	0.125	0.46	0.010	0.012	0.32	0.13	13.05
Alloy D	Manufacturer	0.10	0.45	0.016	0.013	0.32	0.10	12.98
	Bureau of Standards	0.12	....	.....	.....	....	....	13.0
	Referee	0.106	0.46	0.010	0.012	0.33	0.21	13.00

HEAT TREATMENT

Alloy A	Annealed by quenching in water from 2000 F.
Alloy B	Annealed at 1450 F.; cooled in furnace.
Alloy C	Annealed at 1300 F.; cooled in furnace.
Alloy D	Annealed at 1700 F.; cooled in furnace.

Test Procedure:

Instructions to Laboratories.—Each laboratory was supplied with a detailed description of the tests used and with supplementary special information regarding test procedure when requested. The chairman of Subcommittee IV visited many of the laboratories to determine whether the testing apparatus conformed with specifications. No especial effort was made by the subcommittee to assist in or enforce adherence to instructions regarding test procedure. The portions of the general instructions describing details of equipment and procedure that were sent to all laboratories are as follows:

Salt Spray Test:

The salt spray test is rather widely used in corrosion testing investigation. The construction of the salt spray cabinet and the dimensions of the test specimen used are shown in Fig. 5. It is important that the specifications for the cabinet and the preparation of the test specimen be followed by all the participating laboratories, as the nature of the salt spray test makes it possible to obtain a number of variable results if apparently trifling changes are made in the test procedure. The dimensions and finishing instructions regarding the test specimen should be followed by the various laboratories. However, as a control on the effect of specimen preparation as carried out by the different laboratories, standard specimens will be prepared at the Naval Gun Factory, Washington, D. C., and one specimen of each alloy will be forwarded to the testing laboratory for inclusion in the test.

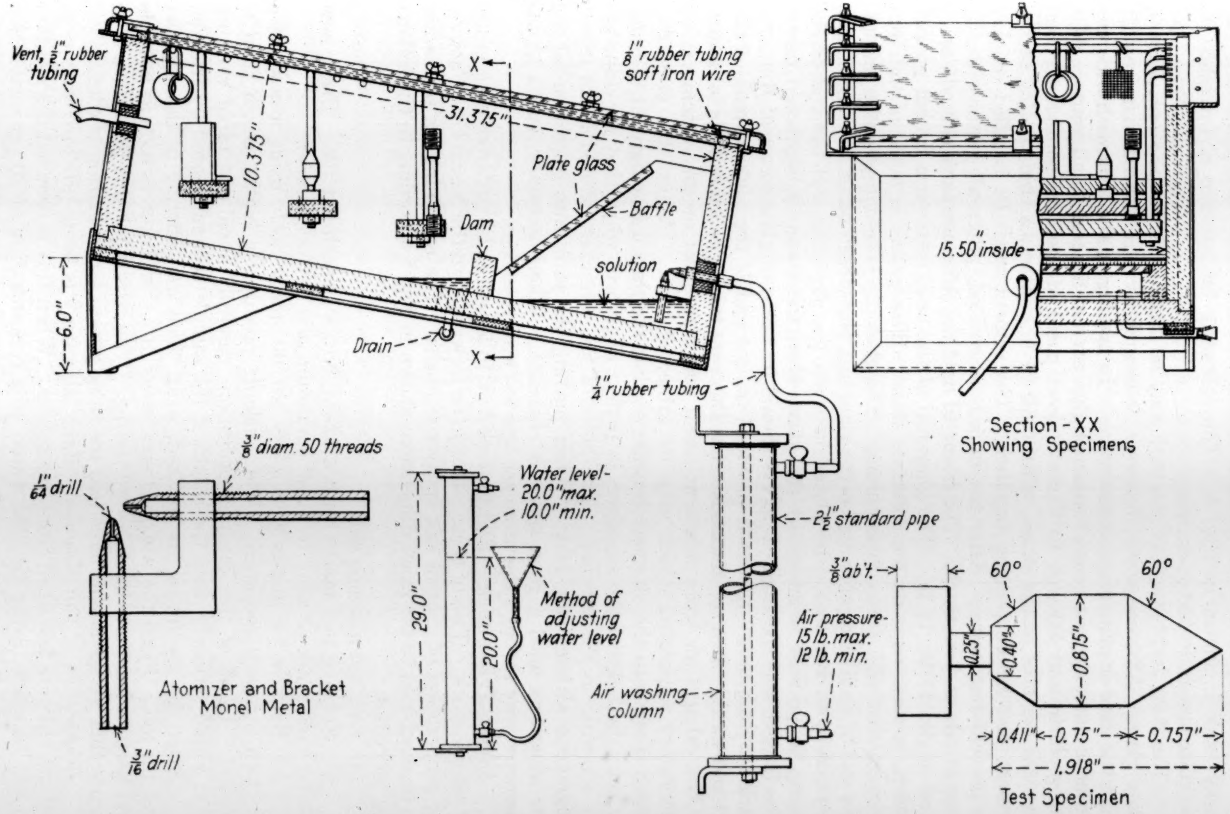

Vent, 1/2" rubber tubing
10.375"
31.375"
X
X
1/8" rubber tubing soft iron wire
Plate glass
Baffle
Dam
solution
6.0"
Drain
1/4" rubber tubing
15.50" inside
Section - XX Showing Specimens
3/8" diam. 50 threads
1/64" drill
3/16" drill
Atomizer and Bracket Monel Metal
Water level- 20.0" max. 10.0" min.
29.0"
20.0"
Method of adjusting water level
2 1/2" standard pipe
Air washing- column
Air pressure- 15 lb. max. 12 lb. min.
3/8" ab't.
60°
60°
0.25"
0.40"
0.875"
0.411"
0.75"
0.757"
1.918"
Test Specimen

FIG. 5.—Salt Spray Test Apparatus and Test Specimen.

Test Equipment.—The general arrangement of the Navy standard salt spray tank is shown in Fig. 5. The following information is furnished to facilitate assembly and operation:

The sides and bottom of the tank may be made of Alberene stone, slate or plate glass. Alberene stone, however, inasmuch as it is worked more readily than the slate or plate glass, is preferable. In making up the tank with Alberene stone or slate, apply a cement made of glycerin and litharge to all joints. Mix the glycerin and litharge to make a good paste of medium consistency and give the surfaces of the stone, which will be in contact, a thin coating of the cement just before putting together. The cement must be handled quickly to prevent hardening. After the tank is assembled, putty all joints with the cement, about $\frac{1}{2}$ in. thick. The frame to hold the Alberene tank is made up of steel angles $1\frac{1}{2}$ by $1\frac{1}{2}$ in. The glass top of the tank rests on a rubber gasket, which, in turn, rests on the Alberene stone. This gasket is made of soft iron wire covered with $\frac{1}{8}$-in. rubber tubing. The glass top is held in place by clamps, one end of each clamp resting on the glass top, the other end on the steel angle. A piece of rubber should be placed between the glass top and the end of the clamp to prevent breakage of the glass when the clamp is tightened down. The hanger and specimen supports should be made of glass to avoid contamination by solution. A vent is provided on one end of the tank to remove the air and spray. It is recommended that this vent tubing be led outside inasmuch as the exhaust air from this vent has a corrosive effect on any machinery or laboratory apparatus which may be subjected to it. Adjust the atomizers which screw into the atomizer bracket so that the thread is a tight fit in order to keep the holes of the atomizers in perfect alignment when they are adjusted by screwing in the bracket. The holes of the atomizers should be in direct alignment without side play. When putting the tank into operation adjust the atomizers until a good spray is obtained. When necessary, run a $\frac{1}{16}$-in. diameter wire through the atomizer tips to clean them out.

Sample Preparation.—Eight pieces 3 in. in length to be cut from each grade of sample stock. Two of these pieces to be forwarded to the Naval Gun Factory for preparation of control salt spray specimens. The remaining six pieces are to be machined to the exact dimensions shown in Fig. 5 according to the following procedure:

(*a*) Finished machine cut;

(*b*) Remove tool marks with a 12-in., No. 3 smooth flat file. Use a new file for each grade of alloy to avoid contamination of the specimen;

(*c*) Remove file marks with a dry No. 00 emery cloth, using a new piece of cloth for each specimen. Wet finishing produces a higher polish than is desired. In all of the finishing operations carefully avoid too rapid working as it would seriously alter the results if the sample became heated by friction.

After the specimens are finished, wrap them immediately in tissue paper and tin foil. Place the wrapped specimens in a desiccator as soon as possible and keep at least one week before testing. The reason for this procedure is to insure that all specimens have had the same period for formation of film.

Preparation of Salt Solution.—Each laboratory is being provided with c. p. sodium chloride furnished from one source. When this is received the solution should be made, using distilled water, to a concentration of 20 per cent NaCl by weight.[1] Before placing a solution in the salt spray cabinet, it should be filtered through asbestos. Sufficient solution will be contained in the bottom of the salt spray cabinet to operate for 72 hr. Ten quarts of solution will keep the atomizer supplied for continuous running over a period of two weeks.

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[1] The salt spray test included in this investigation was not the standard test used by the Navy, see comments by C. E. Margerum, p. 207.

Testing Procedure.—After the specimens have been aged in the manner indicated above for at least one week, they may be removed from the wrapping, carefully washed in alcohol and ether to remove grease, dried and placed on the specimen support. Also, the specimens should be placed at as nearly as possible the same distance from the baffle. Each laboratory should use the specimen support located at about mid-position between the baffle and the end of the cabinet. The air for atomization shall be humidified by passing through the air washing column filled two thirds full with distilled water, maintaining a pressure in the apparatus of about 10 to 12 lb. The condition of the spray inside the cabinet should be observed frequently to insure that uniform distribution and atomization are maintained. Adjustment of air pressure or cleaning of the nozzle will correct any irregularities in this respect. The test should be operated in this manner for each set of four samples for exactly 72 hr. (The cabinet should be placed at a point where the temperature remains fairly constant. All laboratories should run the test between 70 and 80 F.)

At the end of the test the samples should be removed and carefully washed with gentle rubbing. Dry carefully with alcohol and ether and place the samples in the desiccator or by other satisfactory means keep them from exposure to laboratory fumes, etc., until the time for examination by the committee.

Boiling Nitric Acid Test:

This test consists in immersing specimens in 65 per cent boiling nitric acid for 240 hr., the specimens to be removed, weighed, and acid changed every 48 hr.

Sample Preparation.—From the sample bars, cut 8 discs about $\frac{1}{2}$ in. thick for each grade. To finish, machine to $\frac{7}{8}$ in. in diameter by $\frac{1}{2}$ in. in thickness, drill a $\frac{1}{4}$-in. diameter hole at a point $\frac{1}{4}$ in. from the edge, remove tool marks on all surfaces, using dry No. 120 French emery paper, working slowly to avoid friction heating and using new papers for each specimen. All finishing operations must be done slowly to avoid heating. A mirror finish should be avoided.

After the samples are finished, measure carefully for calculation of area, including the inner surface of the hole and determine specific gravity by the water displacement method. Wrap the specimen in tissue paper and tin foil and keep in a desiccator for at least one week before testing.

Testing Equipment.—Use approximately a 1-liter Erlenmeyer flask equipped with a 30-in. reflux condenser, fitted into the flask neck with ground glass joint. Place the flask on an electric hot plate of the three burner, three heat type. A satisfactory arrangement of the apparatus is shown in Fig. 6. Other equipment required includes grinding and polishing equipment of conventional type and a chemical balance for weighing specimens.

Preparation of Solution.—The acid solution to be used should be made from commercially pure nitric acid to a concentration of 65 per cent HNO_3 by weight. An analysis of the acid should be made before testing is begun to determine HNO_3, H_2SO_4, and HCl because the concentration and impurities affect the highly accurate results obtainable, using this test. Strength of acid should be checked occasionally at the conclusion of a test period by titration against standard alkali. A quick test to determine whether acid is being lost by volatilization may be made by holding litmus paper at outlet of condenser tube. If paper turns red, more cooling water is required.

Test Procedure.—When the acid has been prepared and analyzed place 700 cc. in each flask. After the specimens have been carefully measured, determine the density and then thoroughly clean them with alcohol and ether for grease removal, dry and weigh to the third decimal place in grams on an accurate laboratory balance. Place samples on glass hooks in such manner that they are fully immersed and that they are not in contact with each other or the sides of the flask. Three samples of the same grade of alloy may be tested in one flask, providing they do not come in contact. After turning the cooling water through the condensers, switch on the electric hot plate to the high position and after boiling begins, it may be maintained with the switch in the middle position. Maintain boiling continuously for exactly 48 hr. Remove samples at the end of this time, flood with water and rub with a rubber stopper to remove any

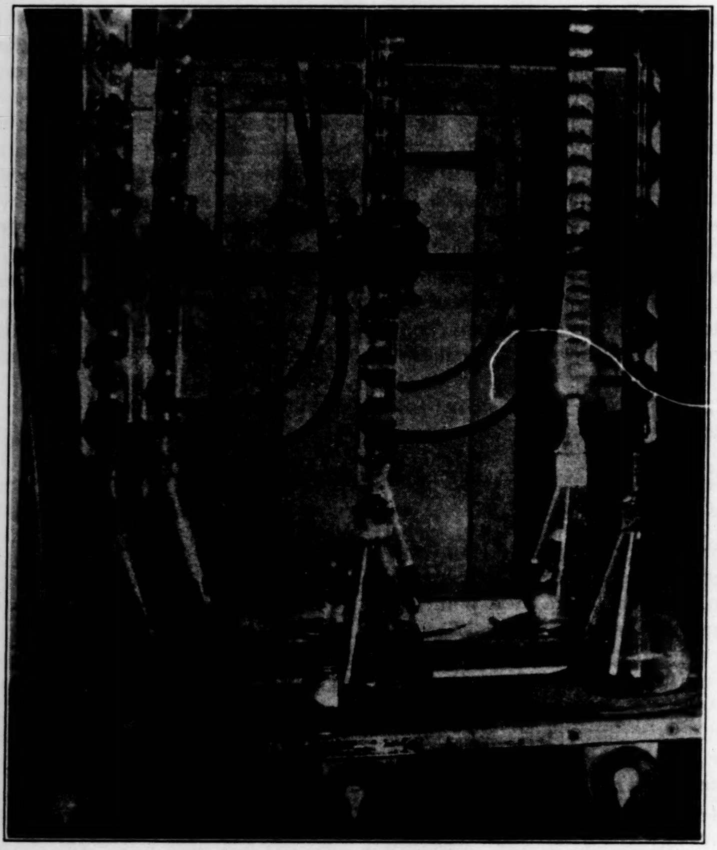

FIG. 6.—Boiling Nitric Acid Test Apparatus.

corrosion products, dry with alcohol and ether and weigh. Repeat this procedure for five 48-hr. periods, making a total testing time of 240 hr. As in the case of the salt spray test, two separate tests are to be made, using four specimens of each grade in each test. Renew acid for each 48-hr. test period.

Calculation of Results.—The data should be reported in inches penetration per month which is calculated from the following:

$$R = \frac{43.9\,W}{AsT}$$

where R = corrosion rate in inches per month;
43.9 = conversion factor;
W = weight loss in grams;
A = total area in square inches;
s = density in grams per cubic centimeter; and
T = time in hours.

The corrosion rate should be determined for each 48-hr. period and for the total 240-hr. test duration.

Copper Sulfate Stain Test:

The copper sulfate stain test represents the quick field test which may be regarded in the nature of a qualitative inspection test.

The procedure is as follows:

The surface of the sample is filed and ground smooth. The finish of the specimen may be obtained by use of No. 120 emery paper. The solution used for making the test consists of the following: 4 g. of $CuSO_4$; 18 g. of H_2SO_4; and 90 g. of H_2O.

Place a drop of this solution upon the metal and note the rate of copper deposit. Entire freedom from copper deposit is an indication of good corrosion resistance. In a case of hardening grades of stainless steel, material improperly hardened for maximum corrosion resistance will show a deposit. The rate of deposit, if it occurs, is the significant value in this test. Six determinations on each specimen should be made.

DISCUSSION OF DATA

Boiling Nitric Acid Test:

The boiling nitric acid test results from all laboratories are shown in Table I.

In Table II which gives the summary of boiling nitric acid test data for all alloys it is shown that the greatest deviation from the weighted average of all laboratories is 25.7 per cent. In this case, Alloy A, the corrosion rates were very low and covered an extreme range of 0.00088 to 0.00122 in. per month. For all alloys and all laboratories 55 per cent of the average corrosion rates deviated from the weighted average less than 6 per cent. The various tabulations presented herein are based upon approximately 2240 single determinations from 12 laboratories. The following tabulation shows the excellent agreement in the data reported. The figures given are the

TABLE I.—BOILING NITRIC ACID TEST RESULTS.

CORROSION RATE IN INCHES PER MONTH.

Test Period[a]		Lab. No. 1	Lab. No. 2	Lab. No. 3	Lab. No. 4	Lab. No. 5	Lab. No. 6	Lab. No. 7	Lab. No. 8	Lab. No. 9	Lab. No. 11	Lab. No. 12	Lab. No. 13	Weighted Average	Percentage Deviation
ALLOY A: 18 PER CENT CHROMIUM, 8 PER CENT NICKEL. ANNEALED BY WATER QUENCHING FROM 2000 F. (1095 C.).															
I	Max	0.00124	0.00119	0.00190	0.0013	0.00125	0.00169	0.00169	0.00123	0.00106	0.00129	0.00127	0.00121		
	Min	0.00109	0.00092	0.00157	0.0010	0.00116	0.00101	0.00123	0.00095	0.00095	0.00113	0.00107	0.00097		
	Avg	0.00117	0.00108	0.00166	0.00115	0.00119	0.00139	0.00143	0.00108	0.00099	0.00122	0.00118	0.00110	0.00122	20.8+
II	Max	0.00100	0.00099	0.00151	0.0010	0.00099	0.00106	0.00129	0.00105	0.00090	0.00093	0.00114	0.00105		
	Min	0.00086	0.00069	0.00097	0.0008	0.00082	0.00071	0.00104	0.00082	0.00075	0.00091	0.00099	0.00099		
	Avg	0.00092	0.00086	0.00113	0.00086	0.00081	0.00091	0.00103	0.00093	0.00082	0.00092	0.00105	0.00102	0.00093	7.9−
III	Max	0.00095	0.00083	0.00114	0.0010	0.00088	0.00098	0.00124	0.00092	0.00101	0.00096	0.00116	0.00095		
	Min	0.00088	0.00071	0.00089	0.0009	0.00081	0.00061	0.00096	0.00076	0.00076	0.00093	0.00101	0.00048		
	Avg	0.00090	0.00078	0.00099	0.00095	0.00084	0.00080	0.00106	0.00084	0.00084	0.00094	0.00107	0.00071	0.00089	11.9−
IV	Max	0.00093	0.00094	0.00151	0.0011	0.00090	0.00094	....	0.00093	0.00092	0.00101	0.00125	....		
	Min	0.00084	0.00087	0.00105	0.0010	0.00084	0.00084	....	0.00081	0.00083	0.00097	0.00110	....		
	Avg	0.00089	0.00090	0.00123	0.00101	0.00088	0.00090	....	0.00088	0.00087	0.00100	0.00116	....	0.00098	3.0−
V	Max	0.00094	0.00097	0.00137	0.0012	0.00098	0.00178	....	0.00091	0.00092	0.00097	0.00133	....		
	Min	0.00088	0.00056	0.00109	0.0011	0.00090	0.00082	....	0.00082	0.00076	0.00092	0.00104	....		
	Avg	0.00091	0.00085	0.00121	0.00114	0.00095	0.00107	....	0.00087	0.00087	0.00095	0.00120	....	0.00099	2.0−
Total Test, 240 hr.	Max	0.00099	0.00093	0.00140	0.00107	0.00099	0.00120	0.00139	0.00095	0.00091	0.00102	0.00123	0.00098		
	Min	0.00092	0.00083	0.00117	0.00096	0.00092	0.00084	0.00112	0.00088	0.00086	0.00099	0.00109	0.00089		
	Avg	0.00096	0.00089	0.00127	0.00102	0.00095	0.00101	0.00122	0.00092	0.00088	0.00100	0.00113	0.00094	0.00101	0
Percentage Deviation from Total Average		4.9−	11.9−	25.7+	1.0+	5.9−	0	21.0+	8.9−	12.8−	1.0−	11.8+	6.9−	0	
Number of Specimens		8	8	8	8	8	6	8	8	8	4	4	8	86	

[a] Test periods were 48 hr. duration each.

TABLE I.—BOILING NITRIC ACID TEST RESULTS (*Continued*).

CORROSION RATE IN INCHES PER MONTH.

Test Period[a]	Lab. No. 1	Lab. No. 2	Lab. No. 3	Lab. No. 4	Lab. No. 5	Lab. No. 6	Lab. No. 7	Lab. No. 8	Lab. No. 9	Lab. No. 11	Lab. No. 12	Lab. No. 13	Weighted Average	Percentage Deviation
ALLOY B: 17.3 PER CENT CHROMIUM. ANNEALED AT 1450 F. (790 C.), FURNACE COOLED.														
I. Max	0.00247	0.00286	0.00501	0.0025	0.00287	0.00291	0.00262	0.00279	0.00271	0.00296	0.00220	0.00247		
Min	0.00214	0.00243	0.00384	0.0021	0.00243	0.00219	0.00229	0.00226	0.00243	0.00279	0.00208	0.00234		
Avg	0.00229	0.00264	0.00439*	0.00220	0.00269	0.00262	0.00244	0.00254	0.00254	0.00289	0.00216	0.00239	0.00248	1.6+
II. Max	0.00217	0.00306	0.00628	0.0025	0.00231	0.00277	0.00241	0.00256	0.00286	0.00217	0.00234	0.00297		
Min	0.00200	0.00255	0.00458	0.0022	0.00195	0.00194	0.00225	0.00215	0.00254	0.00215	0.00223	0.00270		
Avg	0.00209	0.00281	0.00505*	0.00235	0.00214	0.00232	0.00234	0.00236	0.00276	0.00216	0.00232	0.00284	0.00240	1.6−
III. Max	0.00228	0.00319	0.00954	0.0025	0.00225	0.00259	0.00249	0.00225	0.00325	0.00236	0.00263	0.00333		
Min	0.00211	0.00272	0.00601	0.0024	0.00195	0.00106	0.00234	0.00214	0.00236	0.00236	0.00238	0.00181		
Avg	0.00217	0.00303*	0.00797*	0.00245	0.00210	0.00201	0.00242	0.00221	0.00309*	0.00236	0.00251	0.00274	0.00233	4.6−
IV. Max	0.00233	0.00447	0.01406	0.0026	0.00247	0.00295	....	0.00241	0.00404	0.00251	0.00256	....		
Min	0.00222	0.00359	0.00897	0.0024	0.00225	0.00232	....	0.00224	0.00358	0.00246	0.00248	....		
Avg	0.00227	0.00414*	0.01065*	0.00250	0.00236	0.00270	....	0.00232	0.00375*	0.00248	0.00252	....	0.00243	0.4−
V. Max	0.00253	0.00461	0.02163	0.0028	0.00257	0.00306	....	0.00254	0.00460	0.00271	0.00272	....		
Min	0.00236	0.00427	0.01059	0.0024	0.00207	0.00246	....	0.00229	0.00403	0.00263	0.00260	....		
Avg	0.00242	0.00447*	0.01502*	0.00270	0.00235	0.00286	....	0.00241	0.00434*	0.00267	0.00267	....	0.00255	4.5+
Total Test, 240 hr. Max	0.00236	0.00358	0.01107	0.00253	0.00243	0.00281	0.00253	0.00249	0.00345	0.00252	0.00249	0.00291		
Min	0.00221	0.00331	0.00684	0.00236	0.00220	0.00221	0.00223	0.00224	0.00322	0.00250	0.00236	0.00229		
Avg	0.00225	0.00342*	0.00841*	0.00245	0.00232	0.00250	0.00239	0.00237	0.00332*	0.00251	0.00244	0.00265	0.00244	0
Percentage Deviation from Total Average	7.8−	40.2+	245+	0	4.9−	2.5+	2.1−	2.9−	36.1+	2.9+	0	8.6+	0	
Number of Specimens	8	8	8	8	8	6	8	8	8	4	4	8	86	

[a] Test periods were 48 hr. duration each.

* These average data omitted in calculating weighted average.

TABLE I.—BOILING NITRIC ACID TEST RESULTS (*Continued*).

CORROSION RATE IN INCHES PER MONTH.

Test Period[a]		Lab. No. 1	Lab. No. 2	Lab. No. 3	Lab. No. 4	Lab. No. 5	Lab. No. 6	Lab. No. 7	Lab. No. 8	Lab. No. 9	Lab. No. 11	Lab. No. 12	Lab. No. 13	Weighted Average	Percentage Deviation
ALLOY C: 13 PER CENT CHROMIUM. ANNEALED AT 1300 F. (705 C.).															
I	Max	0.01040	0.00970	0.01116	0.0100	0.01011	0.01320	0.01100	0.01205	0.00974	0.01138	0.01075	0.00832		
	Min	0.00957	0.00933	0.00838	0.0088	0.00899	0.01080	0.00953	0.00938	0.00888	0.01093	0.00969	0.00802		
	Avg	0.00993	0.00956	0.00981	0.00936	0.00939	0.01190*	0.01032	0.01098	0.00924	0.01093	0.01029	0.00819*	0.00991	9.0+
II	Max	0.00941	0.00902	0.00908	0.0091	0.00952	0.01180	0.01085	0.01218	0.00888	0.01029	0.01000	0.00742		
	Min	0.00921	0.00839	0.00850	0.0085	0.00837	0.01069	0.01000	0.00877	0.00856	0.01023	0.00961	0.00592		
	Avg	0.00932	0.00872	0.00883	0.00883	0.00890	0.01130*	0.01043	0.01038	0.00878	0.01026	0.00980	0.00657*	0.00947	4.2+
III	Max	0.00928	0.00846	0.00958	0.0095	0.00953	0.01210	0.01037	0.00888	0.00885	0.00954	0.00974	0.00790		
	Min	0.00859	0.00711	0.00903	0.0081	0.00875	0.00881	0.00948	0.00834	0.00826	0.00941	0.00857	0.00395		
	Avg	0.00899	0.00791	0.00930	0.00880	0.00923	0.01002*	0.01006*	0.00858	0.00822	0.00947	0.00914	0.00593*	0.00877	3.5−
IV	Max	0.00888	0.00846	0.01120	0.0090	0.00926	0.01120	....	0.00902	0.00860	0.00988	0.00911	....		
	Min	0.00832	0.00821	0.00988	0.0080	0.00801	0.00995	....	0.00814	0.00816	0.00948	0.00852	....		
	Avg	0.00864	0.00834	0.01053*	0.00834	0.00892	0.01051*	....	0.00851	0.00837	0.00953	0.00882	....	0.00858	5.6−
V	Max	0.00909	0.00859	0.01320	0.0091	0.01055	0.01050	....	0.00889	0.00854	0.01006	0.00908	....		
	Min	0.00875	0.00816	0.00999	0.0081	0.00872	0.00944	....	0.00814	0.00837	0.00949	0.00838	....		
	Avg	0.00892	0.00831	0.01156*	0.00844	0.00957	0.00984	....	0.00849	0.00842	0.00978	0.00878	....	0.00885	2.6−
Total Test, 240 hr.	Max	0.00933	0.00868	0.01025	0.00898	0.00963	0.01100	0.01060	0.01023	0.00873	0.01006	0.00972	0.00789		
	Min	0.00893	0.00707	0.00977	0.00875	0.00866	0.00929	0.00969	0.00855	0.00852	0.00993	0.00904	0.00614		
	Avg	0.00917	0.00839	0.01000*	0.00884	0.00915	0.00989	0.01034*	0.00939	0.00860	0.01000	0.00937	0.00694*	0.00909	0
Percentage Deviation from Total Average		0.9+	7.7−	10.0+	2.7−	0.1+	8.8+	13.7+	3.3+	5.4−	10.0+	3.1+	22.5−	0	
Number of Specimens		8	8	8	8	8	6	8	8	8	4	4	8	86	

[a] Test periods were 48 hr. duration each.

* These average data omitted in calculating weighted average.

TABLE I.—BOILING NITRIC ACID TEST RESULTS (*Continued*).

CORROSION RATE IN INCHES PER MONTH.

Test Period[a]		Lab. No. 1	Lab. No. 2	Lab. No. 3	Lab. No. 4	Lab. No. 5	Lab. No. 6	Lab. No. 7	Lab. No. 8	Lab. No. 9	Lab. No. 11	Lab. No. 12	Lab. No. 13	Weighted Average	Percentage Deviation
ALLOY D: 13 PER CENT CHROMIUM. ANNEALED AT 1700 F. (925 C.).															
I	Max	0.00987	0.00913	0.01020	0.0103	0.00934	0.01120	0.01019	0.01113	0.00902	....	0.02356	0.00697		
	Min	0.00868	0.00834	0.00803	0.0093	0.00829	0.00809	0.00937	0.00839	0.00843	....	0.02186	0.00534		
	Avg	0.00926	0.00875	0.00913	0.00957	0.00874	0.00986	0.00988	0.00981	0.00868	....	0.02261*	0.00614*	0.00928	5.0+
II	Max	0.00919	0.00852	0.00866	0.0095	0.00943	0.01020	0.00954	0.01102	0.00866	....	0.02825	0.00710		
	Min	0.00822	0.00754	0.00808	0.0088	0.00718	0.00889	0.00902	0.00829	0.00836	....	0.02627	0.00361		
	Avg	0.00878	0.00817	0.00834	0.00916	0.00856	0.00948	0.00930	0.00971	0.00849	....	0.02726*	0.00482*	0.00887	0.3+
III	Max	0.00895	0.00830	0.00874	0.0098	0.00898	0.01100	0.00970	0.00846	0.00852	....	0.02883	0.00633		
	Min	0.00807	0.00737	0.00783	0.0086	0.00826	0.00514	0.00887	0.00794	0.00783	....	0.02560	0.00214		
	Avg	0.00853	0.00787	0.00827	0.00920	0.00861	0.00912	0.00992	0.00828	0.00822	....	0.02724*	0.00422*	0.00867	1.9–
IV	Max	0.00900	0.00836	0.00924	0.0106	0.00923	0.01150	....	0.00875	0.00858	....	0.02876	....		
	Min	0.00848	0.00778	0.00897	0.0089	0.00760	0.00880	....	0.00768	0.00804	....	0.02604	....		
	Avg	0.00876	0.00819	0.00937	0.00946	0.00842	0.00999	....	0.00811	0.00826	....	0.02702*	....	0.00877	0.8–
V	Max	0.00865	0.00851	0.00907	0.0092	0.01002	0.01100	....	0.00840	0.00820	....	0.02899	....		
	Min	0.00787	0.00781	0.00861	0.0083	0.00828	0.00929	....	0.00764	0.00789	....	0.02617	....		
	Avg	0.00827	0.00829	0.00878	0.00859	0.00916	0.00989	....	0.00792	0.00804	....	0.02717*	....	0.00857	3.0–
Total Test, 240 hr.	Max	0.00900	0.00856	0.00884	0.00966	0.00927	0.01000	0.00975	0.00956	0.00841	....	0.02768	0.00629		
	Min	0.00830	0.00774	0.00866	0.00906	0.00824	0.00889	0.00923	0.00800	0.00817	....	0.02526	0.00426		
	Avg	0.00872	0.00827	0.00873	0.00927	0.00875	0.00952	0.00947	0.00878	0.00828	....	0.02625*	0.00509*	0.00884	0
Percentage Deviation from Total Average		1.3–	6.4–*	1.3–	4.9+	1.0–	7.7+	7.1+	0.7–	6.3–	....	197.0+	42.4–	0	
Number of Specimens		8	8	8	8	8	6	8	8	8	....	4	8	82	

[a] Test periods were 48 hr. duration each.

* These average data omitted in calculating weighted average.

TABLE II.—SUMMARY OF BOILING NITRIC ACID TEST DATA, ALL ALLOYS.

NOTE.—R = Average corrosion rate for 240 hr., expressed in inches per month.
P = Percentage deviation from weighted average of all laboratories.
W+ = Maximum per cent above weighted average for a single determination.
W− = Maximum per cent below weighted average for a single determination.
Roman numerals indicate period of test in which maximum deviation occurred.

		Lab. No. 1	Lab. No. 2	Lab. No. 3	Lab. No. 4	Lab. No. 5	Lab. No. 6	Lab. No. 7	Lab. No. 8	Lab. No. 9	Lab. No. 11	Lab. No. 12	Lab. No. 13	Weighted Average and Total	Lab. No.
Alloy A	R	0.00096	0.00089	0.00127	0.00102	0.00095	0.00101	0.00122	0.00092	0.00088	0.00100	0.00113	0.00094	0.00101	...
	P	4.9−	11.9−	25.7+	1.0+	5.9−	0	21.0+	8.9−	12.8−	1.0−	11.8+	6.9−	25.7+	3
	W+	27 I	33 I	50 I	27 I	28 I	67 I	38 I	26 I	20 I	28 I	32 V	28 I	67 I	6
	W−	12 IV	37 V	30 III	21 II	15 III	34 III	21 III	12 IV	15 II	10 II	2 II	49 III	49 III	13
Alloy B	R	0.00225	0.00342*	0.00841*	0.00245	0.00232	0.00250	0.00239	0.00237	0.00332*	0.00251	0.00244	0.00265	0.00244	...
	P	7.8−	40.2+	245+	0	4.9−	2.5+	2.1−	2.9−	36.1+	2.9+	0	8.6+	8.6+	13
	W+	....	75 V	719 V	6 V	21 I	22 IV	10 I	18 I	39 V	21 I	10 V	26 III	26 III	13
	W−	25 II	8 I	....	20 I	10 II	58 III	6 II	10 III	29 III	12 II	15 I	11 I	58 III	6
Alloy C	R	0.00917	0.00839	0.01000*	0.00884	0.00915	0.00989	0.01034*	0.00939	0.00860	0.01000	0.00937	0.00694*	0.00909	...
	P	0.9+	7.7−	10.0+	2.7+	0.1+	8.8+	13.7+	3.3+	5.4−	10.0+	3.1+	22.5−	10.0+	11
	W+	11 I	6 I	42 V	7 I	13 V	42 I	18 I	40 I	5 I	25 I	18 I	....	42 I	6
	W−	11 IV	24 III	10 I	14 IV	6 III	5 III	2 III	13 V	13 IV	....	8 V	58 III	24 III	2
Alloy D	R	0.00872	0.00827	0.00873	0.00927	0.00875	0.00952	0.00947	0.00878	0.00828	....	0.02625*	0.00509*	0.00884	...
	P	1.3−	6.4−	1.3−	4.9+	1.0−	7.7+	7.1+	0.7−	6.3−	....	197+	42.4−	7.7+	6
	W+	11 I	3 I	15 I	19 IV	13 V	30 IV	15 I	25 I	2 I	....	228 V	....	30 IV	6
	W−	11 V	17 III	11 III	7 V	6 III	42 III	1 III	13 V	12 III	....	148 I	76 III	42 III	6
Maximum of al lAlloys	P	−7.8 B	+40.2 B	+245 B	+4.9 D	−5.9 A	+8.8 C	+21 A	−8.9 A	+36.1 B	+10 C	+197 D	−42.4 D	+25.7 A	3
	W+	27 A I	75 B V	719 B V	27 A I	28 A I	67 A I	38 A I	40 C I	39 B V	28 A I	228 D V	28 A I	67 A I	6
	W−	25 B II	37 A VII	30 A III	21 A II	15 A III	58 B III	21 A III	13 C V	29 B III	25 C I	148 D I	76 D III	58 B III	6

* These average data omitted in calculating weighted average.

percentage of total average rate values falling within various ranges of deviation indicated.

RANGE OF PERCENTAGE DEVIATION	PERCENTAGE OF AVERAGE VALUES[a] ALLOY *A*	ALLOY *B*	ALLOY *C*	ALLOY *D*	TOTAL
0 to 6	42	70	50	67	55
6 to 12	33	20	33	33	30
12 to 24	8	10	17	..	9
Above 24	17	..	..	..	6

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[a] Five average determinations were omitted from a total of 47 determinations, in calculating the data of this table.

In several instances, data were omitted in calculating averages for the various tabulations. These omissions are indicated by an asterisk against those values in the table. It was apparent that these data were sufficiently above or below the majority of the data to justify the omission. Laboratory No. 3 used 70.1 per cent HNO_3 and laboratory No. 13 reported difficulty in keeping the acid boiling. Errors were found in calculations of corrosion rate in some cases. In this manner some of the discrepancies may be explained.

The acid strengths reported by the various laboratories are as follows:

LABORATORY	PERCENTAGE HNO_3, ORIGINAL
No. 1	65.44
No. 2	65
No. 3	70.10
No. 4	65
No. 5	65.2
No. 6	65
No. 7	65
No. 8	65.0
No. 9	66.8
No. 11	65
No. 12	65
No. 13	65

ALLOY	AVERAGE PERCENTAGE HNO_3 DURING TEST LABORATORY No. 1	LABORATORY No. 5	LABORATORY No. 9
A	65.32	64.4	66.1
B	65.26	64.4	66.3
C	65.25	64.4	65.9
D	65.17	64.5	65.7
Min	65.14	64.1	64.0
Max	65.35	65.0	66.8
Period Reported	I III V	II II III IV V	I II III

Salt Spray Test:

An attempt has been made to evaluate the qualitative data (Table III) that were obtained from observation of salt spray test specimens. The method of classification is somewhat different from that specified by the Navy, but the same bacic scheme is used. The number of pits on each specimen has been determined approximately

TABLE III.—SALT SPRAY TEST RESULTS.

Definition of rating; rating based on cone surface only:

Rating A = No stain, blemish, or pits.
Rating B = Slight stain only. No pits or etching.
Rating C = Considerable stain. Local etching. Few pits.
Rating D = General staining. Rust. Etching. Several pits.
Rating E = Heavy stain. Rust. Scale. Etching. Pits.

NOTE.—Approximate number of visible pits are indicated by subscript on Ratings C and D.

Laboratory	Specimen Rating per Modified Navy Specifications[a]										Remarks
	NGF Specimens		Specimens Prepared by Each Laboratory								
	1	2	1	2	3	4	5	6	7	8	
						ALLOY A					
No. 1	A	C_3	A	C_2	..	..	..	..	..	..	Pits etched.
No. 2	A	A	..	..	B	B	B	B	B	B	No pits. No etching.
No. 3	C_1	A	B	C_1	C_1	B	B	B	..	..	Pits etched.
No. 4	C_2	C_4	..	..	C_2	B	C_3	C_3	C_3	C_3	Heavy rust. Pits etched.
No. 5	C_1	B	B	B	A	A	A	A	..	..	Pits etched.
No. 6	..	..	A	A	A	A	A	A	..	..	No attack.
No. 9	B	B	..	..	B	B	B	B	B	B	No pits. No etching. Slight stain.
No. 11	C_1	C_1	B	C_1	C_1	C_1	C_3	C_5	..	..	Pits etched. Several.
No. 12	C_1	B	B	C_1	B	B	B	B	..	..	No etching.
No. 13	..	..	A	C_1	A	B	C_2	C_1	C_1	A	No etching.
No. 15	A	C_3	..	..	A	A	A	A	C_1	C_2	Pits etched.
						ALLOY B					
No. 1	C_4	C_2	C_1	C_3	..	..	..	..	..	..	Staining. No etching.
No. 2	C_4	C_7	..	..	C_1	B	C_2	C_2	C_4	C_4	No etching.
No. 3	C_3	C_3	C_3	D_2	C_3	C_4	C_2	C_2	..	..	Occasional etching.
No. 4	D_7	D_3	..	..	C_4	C_3	C_2	C_3	C_3	C_4	Heavy staining. No etching.
No. 5	C_2	C_3	C_2	C_2	C_3	C_3	C_2	C_3	..	..	No etching.
No. 6	C_1	C_1	B	B	B	B	B	..	..	..	Light staining. No etching.
No. 9	C_1	C_1	..	..	C_1	C_1	C_1	C_2	B	C_1	Medium staining. No etching.
No. 11	D_7	D_{11}	C_2	C_2	C_2	C_3	D_7	C_6	..	..	Medium staining. Pits etched.
No. 12	C_3	C_3	C_3	C_2	C_2	C_1	C_1	C_1	..	..	Considerable stain. No etching.
No. 13	..	..	C_4	C_3	C_5	C_4	C_4	C_4	C_3	C_2	Considerable stain. No etching.
No. 15	B	C_2	..	..	A	A	A	C_2	C_2	C_2	Occasional etching.
						ALLOY C					
No. 1	D_{13}	D_{13}	D_{13}	D_{13}	..	..	..	..	..	..	General etching.
No. 2	D_8	D_{12}	..	..	D_6	D_7	D_6	D_{10}	D_8	D_9	Pit areas etched.
No. 3	D_7	C_4	D_{11}	D_8	D_5	D_5	D_5	D_8	..	..	General etching.
No. 4	E	E	..	..	D_6	E	E	E	E	E	Heavy rust. Etching.
No. 5	D_8	D_6	D_8	C_4	C_4	C_4	C_4	C_5	..	..	General etching.
No. 6	C_3	C_2	C_6	C_3	C_4	C_3	C_4	C_4	..	..	Pits etched.
No. 9	C_4	C_5	..	..	C_4	C_2	C_3	C_4	C_4	C_4	Pit areas etched.
No. 11	D_{10}	D_{10}	D_9	D_9	D_9	D_{13}	D_{13}	D_{13}	..	..	General etching and pits.
No. 12	D_4	D_4	D_4	D_4	D_4	D_4	D_4	D_4	..	..	General etching. Spotty.
No. 13	..	..	D_6	D_5	C_4	D_4	D_5	D_4	D_4	D_5	Pit areas etched.
No. 15	D_6	D_4	..	..	C_4	C_5	C_4	D_7	D_7	D_8	Pit areas etched.
						ALLOY D					
No. 1	D_2	D_7	D	D_5	..	..	..	..	..	..	Etching.
No. 2	D_6	D_8	..	..	C_4	C_4	C_5	D_6	D_6	D_{10}	Pits etched.
No. 3	D_4	D_4	D_2	D_3	D_4	E	D_3	D_4	..	..	General etching.
No. 4	E	E	..	..	E	E	E	E	E	E	Heavy rusting and pits.
No. 5	D_9	D_{10}	D_7	D_7	D_7	D_4	D_4	D_4	..	..	General etching.
No. 6	C_3	D_3	D_2	C_4	C_4	C_4	C_4	C_4	..	..	Pit areas etched.
No. 9	D_2	D_3	..	..	C_2	C_3	C_2	D_2	D_2	D_3	Slight etching.
No. 11	D_3	D_{10}	D_6	D_8	D_6	D_{13}	D_{13}	D_{12}	..	..	General etching and pits.
No. 12	D	D	E	E	E	E	E	E	..	..	Heavy rusting and spots.
No. 13	..	..	D_6	D_2	D_5	D_3	D_9	D_8	D_5	D_1	Pit areas etched.
No. 15	D_2	D_5	..	..	D	D	D_2	D_6	D_7	D_7	Pit areas etched.

[a] Braces enclose specimens which were tested together in sets of three each.

Table IV.—Number of Specimens for Each Rating and Number of Pits Observed in the Salt Spray Test.

Laboratory	Alloy A				Alloy B						Alloy C					Alloy D				
	No. of A Ratings	No. of B Ratings	No. of C Ratings	No. of Pits, C Ratings	No. of A Ratings	No. of B Ratings	No. of C Ratings	No. of Pits, C Ratings	No. of D Ratings	No. of Pits, D Ratings	No. of C Ratings	No. of Pits, C Ratings	No. of D Ratings	No. of Pits, D Ratings	No. of E Ratings	No. of C Ratings	No. of Pits, C Ratings	No. of D Ratings	No. of Pits, D Ratings	No. of E Ratings
No. 1	2	..	2	5	..	..	4	10	..	..	..	..	4	52	..	..	..	4	14	..
No. 2	2	6	..	..	..	1	7	25	..	..	..	..	8	66	..	3	13	5	36	..
No. 3	1	4	3	3	..	..	7	20	1	2	1	4	7	43	..	..	..	7	24	1
No. 4	..	1	7	20	..	..	6	20	2	10	..	..	1	6	7	..	..	..	..	8
No. 5	4	3	1	1	..	..	8	20	..	..	5	21	3	22	..	..	..	8	52	..
No. 6	6	..	..	..	..	5	2	2	..	..	8	28	..	..	..	6	23	2	5	..
No. 9	..	8	..	..	..	1	7	8	..	..	8	30	..	..	..	3	7	5	12	..
No. 11	..	1	7	13	..	..	5	14	3	25	..	..	8	86	..	..	..	8	71	..
No. 12	..	6	2	2	..	..	8	16	..	..	..	..	8	32	..	..	..	2	..	6
No. 13	3	1	4	5	..	..	8	29	..	..	1	4	7	33	..	..	..	8	34	..
No. 15	5	..	3	6	3	1	4	8	..	..	3	13	5	29	..	..	..	8	29	..
Total	23	30	29	55	3	8	66	172	6	37	26	100	51	369	7	12	43	57	277	15
Percentage of Total Average	28	37	35	1.9	4	9	80	2.6	7	6.2	31	4.0	61	7.2	8	14	3.6	68	4.8	18

Table V.—Number of Specimens of All Alloys Showing Different Ratings in Salt Spray Test.

Note.—NGF Spec. = Specimens prepared by Naval Gun Factory.
Lab. Spec. = Specimens prepared by each laboratory.

Laboratory	A Rating				B Rating				C Rating				D Rating				E Rating				Number of Pits			
	NGF Specimens		Laboratory Specimens		NGF Specimens		Laboratory Specimens		NGF Specimens		Laboratory Specimens		NGF Specimens		Laboratory Specimens		NGF Specimens		Laboratory Specimens		NGF Specimens		Laboratory Specimens	
	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Average	No.	Average
No. 1	1	12.5	1	12.5	..	....	..	....	3	37.5	3	37.5	4	50	4	50	..	....	..	....	44	5.5	47	5.9
No. 2	2	25	..	....	..	....	7	37.5	2	25	8	33.3	4	50	9	29.2	..	....	..	....	45	5.6	95	3.9
No. 3	1	12.5	..	....	..	....	4	16.7	3	37.5	7	29.2	4	50	12	50	..	....	1	4.1	26	3.3	68	2.8
No. 4	..	....	..	....	..	....	1	4.1	2	25	11	45.9	2	25	1	4.1	4	50	11	45.9	16	2.0	30	1.2
No. 5	..	....	4	16.7	1	12.5	2	8.2	3	37.5	11	45.9	4	50	7	29.2	..	....	..	....	39	4.9	77	3.1
No. 6	..	....	6	26.1	..	....	5	21.7	5	23.3	11	48.0	1	16.7	1	4.2	..	....	..	....	13	2.2	45	2.0
No. 9	..	....	..	....	2	25	7	29.2	4	50	14	58.3	2	25	3	12.5	..	....	..	....	16	2.0	41	1.7
No. 11	..	....	..	....	..	....	1	4.1	2	25	10	41.7	6	75	13	54.2	..	....	..	....	53	6.6	156	6.5
No. 12	..	....	..	....	1	12.5	5	20.8	3	37.5	7	29.2	4	50	6	25	..	....	6	25	15	1.9	35	1.4
No. 13	..	....	3	9.4	..	....	1	3.0	..	....	13	40.6	..	....	15	47	..	....	..	....	..	....	105	3.3
No. 15	1	12.5	7	29.2	1	12.5	..	....	2	25	8	33.3	4	50	9	37.5	..	....	..	....	22	2.7	63	2.6
Total	5	6.5	21	8.2	5	6.5	33	12.9	29	37.2	103	40.4	35	44.9	80	31.4	4	4.9	18	7.1	289	3.7	762	2.97

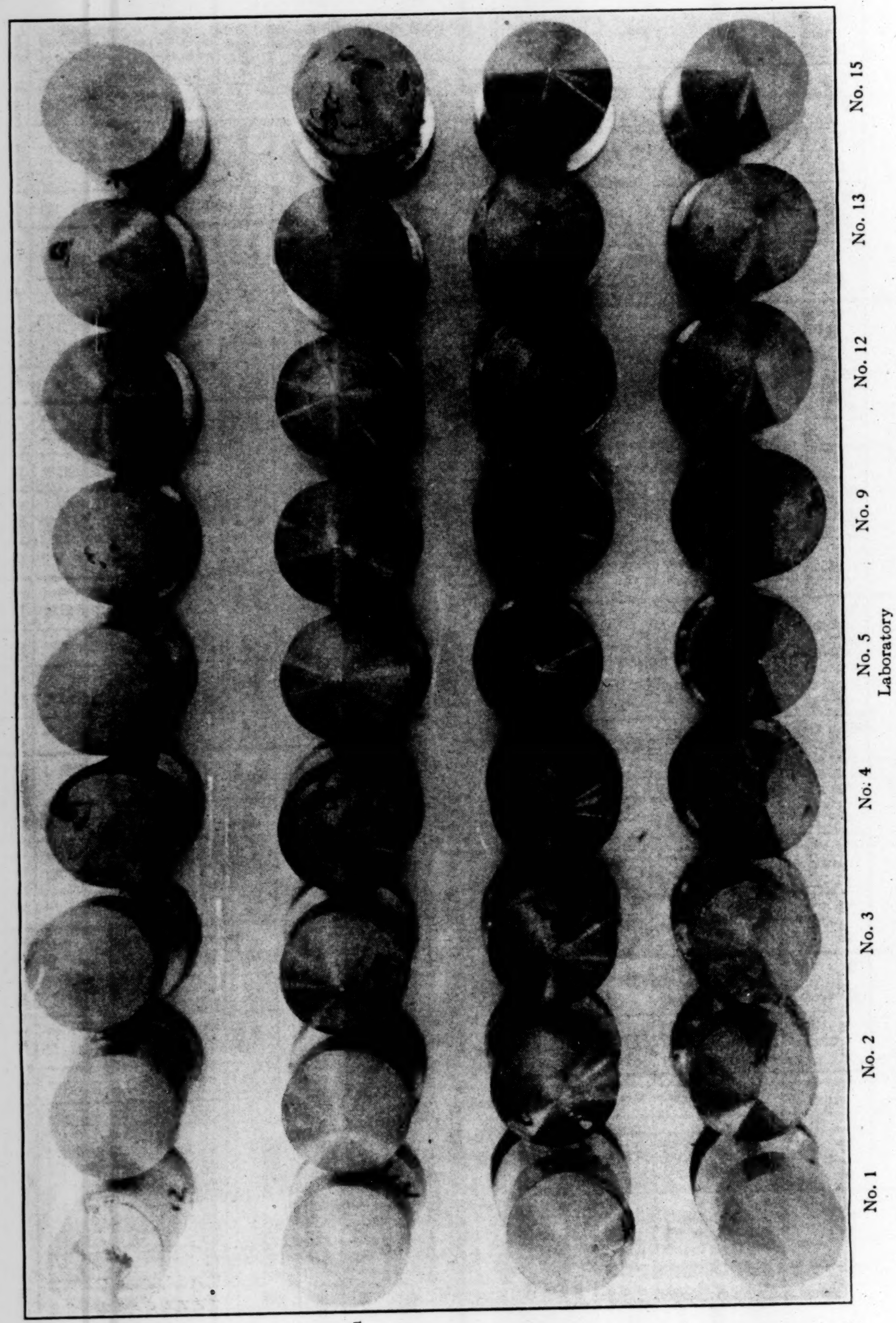
No. 1
No. 2
No. 3
No. 4
No. 5
Laboratory
No. 9
No. 12
No. 13
No. 15
NGF Specimen
NGF Specimen
Worst
Least

FIG. 7.—Photographs of Alloy A Specimens from All Laboratories After Salt Spray Test.

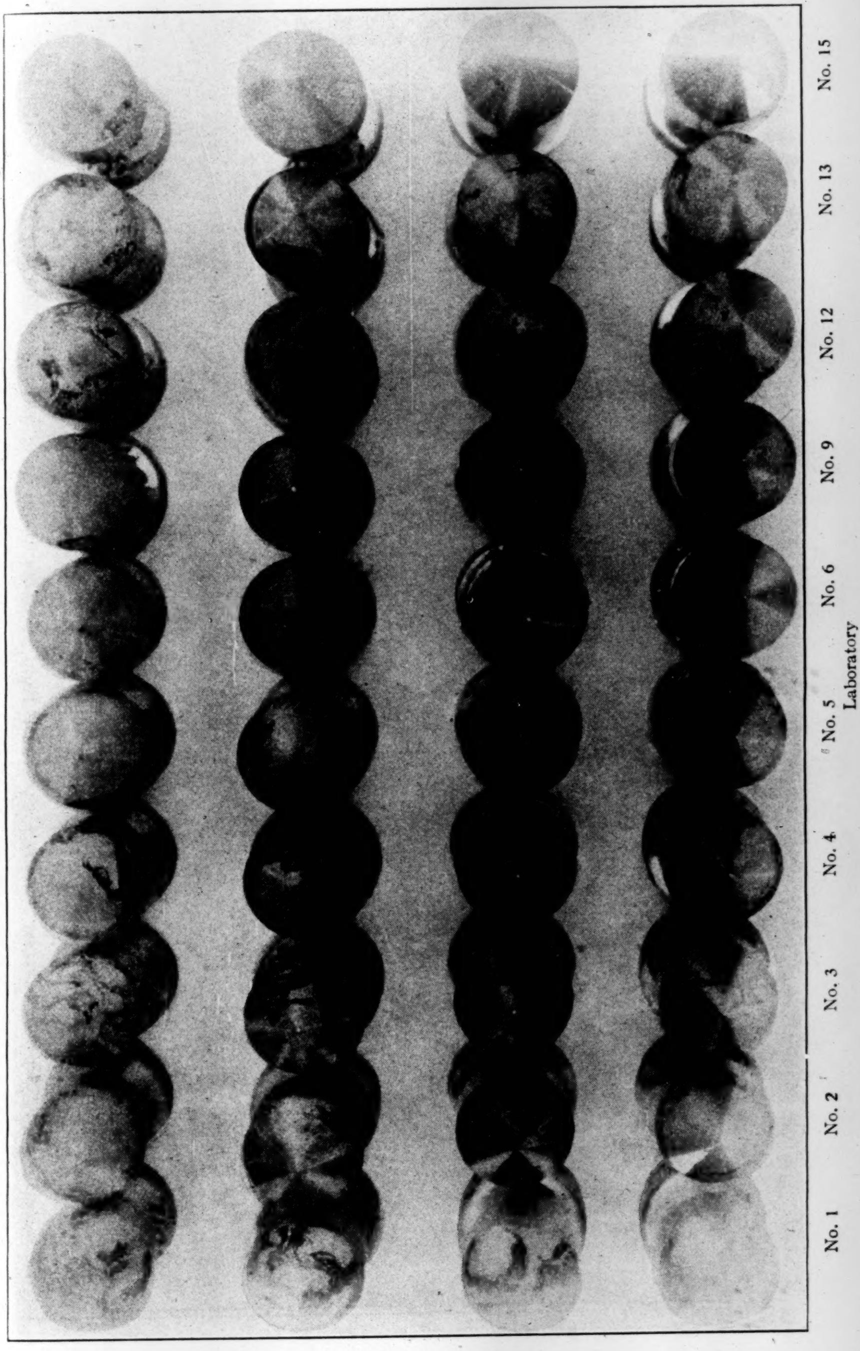
No. 1
No. 2
No. 3
No. 4
No. 5
No. 6
No. 9
No. 12
No. 13
No. 15
Laboratory
NGF Specimen
NGF Specimen
Worst
Least

FIG. 8.—Photographs of Alloy B Specimens from All Laboratories After Salt Spray Test.

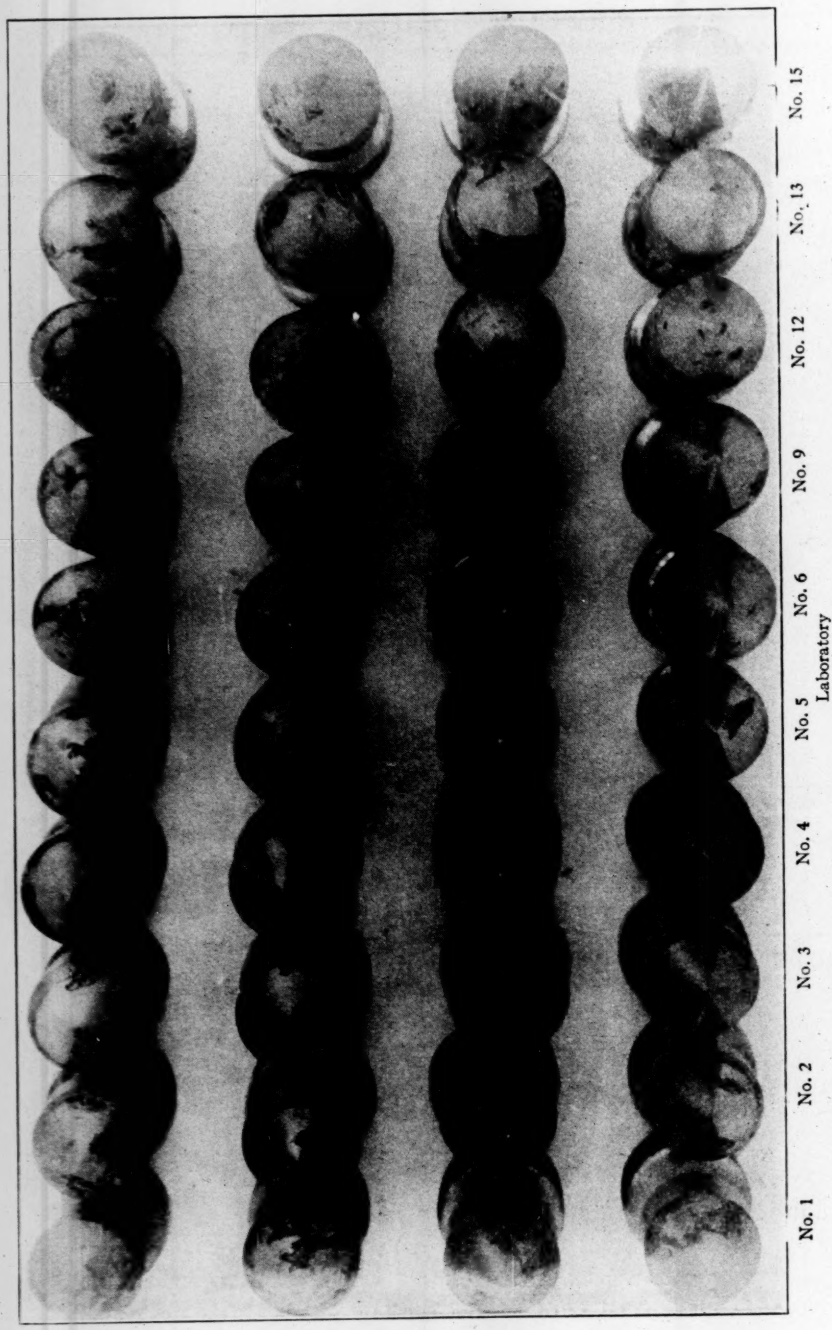
NGF Specimen
NGF Specimen
Worst
Least
No. 1
No. 2
No. 3
No. 4
No. 5
No. 6
No. 9
No. 12
No. 13
No. 15
Laboratory

FIG. 9.—Photographs of Alloy C Specimens from All Laboratories After Salt Spray Test.

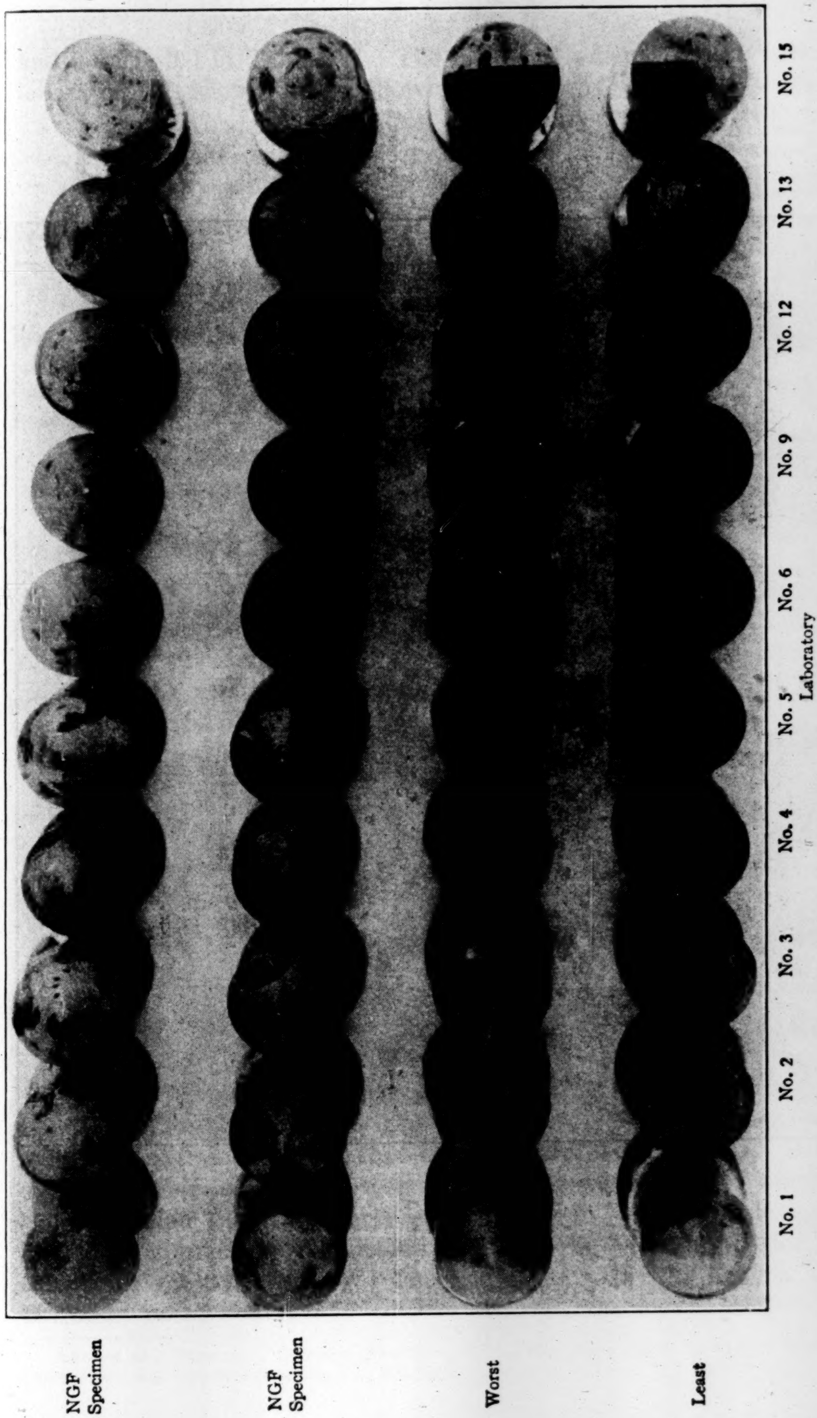
No. 1
No. 2
No. 3
No. 4
No. 5
No. 6
Laboratory
No. 9
No. 12
No. 13
No. 15
NGF Specimen
NGF Specimen
Worst
Least

FIG. 10.—Photographs of Alloy D Specimens from All Laboratories After Salt Spray Test.

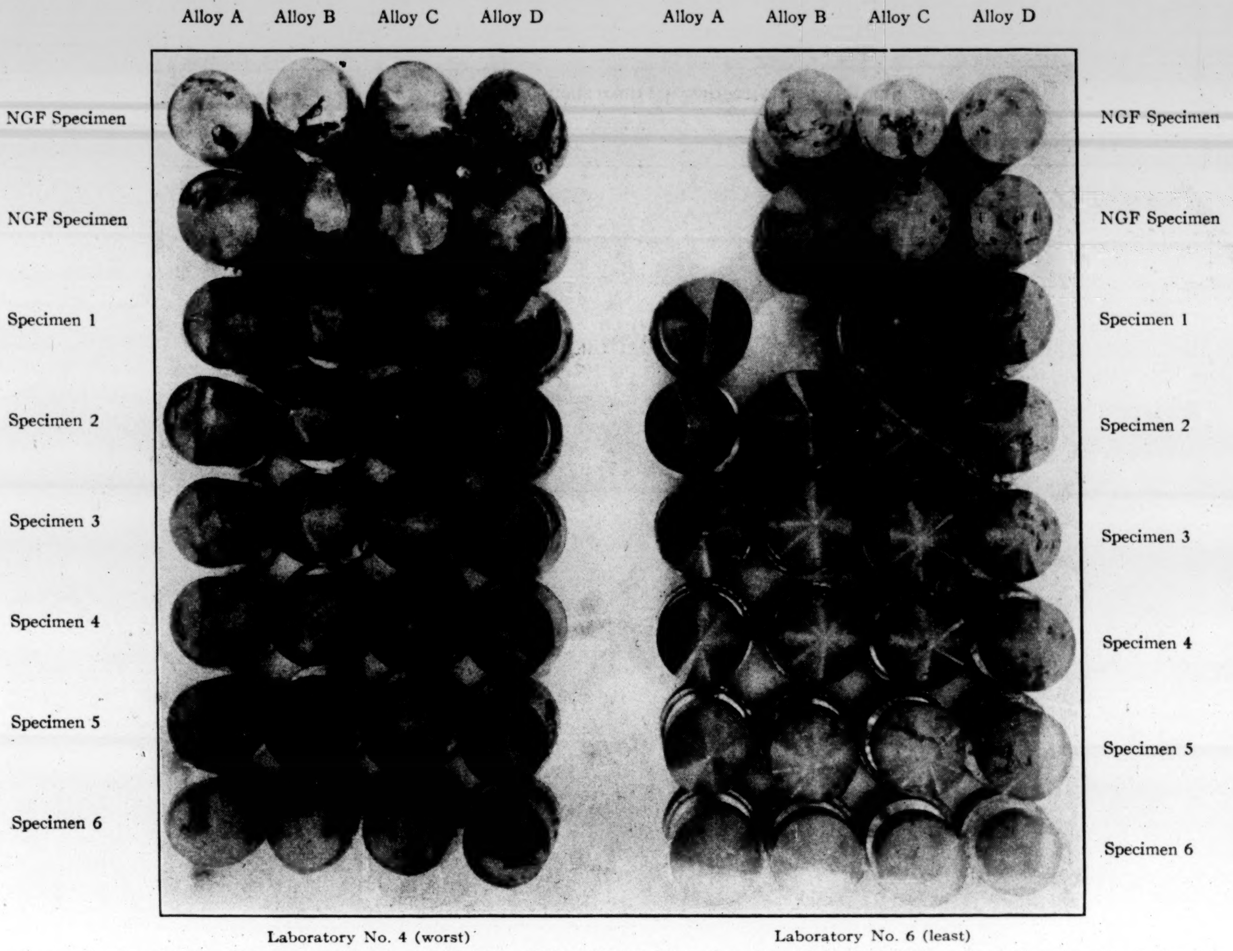
Alloy A
Alloy B
Alloy C
Alloy D
Alloy A
Alloy B
Alloy C
Alloy D
NGF Specimen
NGF Specimen
Specimen 1
Specimen 2
Specimen 3
Specimen 4
Specimen 5
Specimen 6
NGF Specimen
NGF Specimen
Specimen 1
Specimen 2
Specimen 3
Specimen 4
Specimen 5
Specimen 6
Laboratory No. 4 (worst)
Laboratory No. 6 (least)

FIG. 11.—Specimens of Alloys A, B, C and D from Laboratories Nos. 4 and 6 After Salt Spray Test Showing Variations in

INT IN BINDING

and is recorded in Table IV. The degree of severity at the various laboratories is shown in the following tabulation:

	BASED ON GENERAL APPEARANCE ONLY. LABORATORY	BASED ON NUMERICAL RATING (D + E)[a]. LABORATORY
Least severely attacked	No. 6	No. 6
	No. 15	No. 9
	No. 9	No. 5
	No. 3	No. 2
Difference slight. Questionable	No. 13	No. 15
	No. 2	No. 13
	No. 1	No. 12
	No. 5	No. 1
	No. 11	No. 3
	No. 12	No. 11
Most severely attacked	No. 4	No. 4

[a] See Table III.

The value of the salt spray test may be enhanced by making the data quantitative. A method of presenting salt spray test data is contained in a recent paper by Arness and Ostrofsky.[1] By a combination of photography and planimeter measurement the affected area may be accurately determined, in a manner similar to that suggested in the paper mentioned.

While there are some points of agreement in the results, it may be stated that the salt spray test does not compare favorably with the boiling nitric acid test in yielding reproducible data. Based upon general appearance of the specimens and upon numerical rating, as presented in Tables III, IV and V, there is reasonably close agreement in the extremes of attack. Photographs of the four alloys showing the NGF specimens and the worst and least corroded specimens after the salt spray test from all the laboratories are shown in Figs. 7 to 10.

From careful examination of the specimens, the following general comments may be made:

1. In most instances, the specimens prepared at the Naval Gun Factory (NGF) were more severely attacked than those prepared at the other laboratories. The surface finish on the NGF specimens was somewhat coarser in texture than on the laboratory specimens. However, the evidence of these tests was not strong enough to warrant the conclusion that the degree of difference in surface finish noted caused an appreciable difference in attack. Further information on this point may be had by reference to the paper by Arness and Ostrofsky noted above.

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[1] Arness and Ostrofsky, "Corrosion Resistance of Iron Chromium Alloys in Various Media," *Transactions*, Am. Soc. Steel Treating, Vol. XX, 1932.

Laboratory No. 4 (worst) Laboratory No. 6 (least)

FIG. 11.—Specimens of Alloys A, B, C and D from Laboratories Nos. 4 and 6 After Salt Spray Test Showing Variations in

2. There was considerable variation in the attack on specimens of the same alloy tested in a given laboratory. There was considerable variation in the severity of attack on specimens from the same bar tested by different laboratories. Both of these points are apparent in the photograph of specimens tested by laboratories Nos. 4 and 6, shown in Fig. 11.

TABLE VI.—COPPER SULFATE STAIN TEST RESULTS.

TIME RANGE FOR COPPER DEPOSITION IN SECONDS.

Laboratory		Alloy C					Alloy D				
		Specimens				Total Range and Mean Average	Specimens				Total Range and Mean Average
		1	2	3	4		1	2	3	4	
No. 1	Range	60	60	60	60	......	180–420	180–300	180–270	180–300	180–420
	Average	60	60	60	60	60	208	240	216	234	224
No. 2	Range	45–100	20–70	40–60	20–60	20–100	30–50	30–90	35–90	30–80	30–90
	Average	57	47	55	38	49	42	43	49	53	47
No. 3	Range	270–485	270–390	190–455	255–385	190–485	128–220	130–185	145–220	145–230	128–230
	Average	334	320	333	312	249	161	162	172	185	170
No. 4	Range	60–140	60–110	60–180	60–80	60–180	85–130	70–120	40–95	80–120	70–130
	Average	90	93	94	78	89	101	104	78	99	95
No. 5	Range	.....	.....	.....	.....	......	.....	.....	.....	.....	......
	Average	.....	.....	.....	.....	95	.....	.....	.....	.....	120
No. 6	Range	.....	.....	.....	.....	......	.....	.....	.....	.....	......
	Average	.....	.....	.....	.....	90	.....	.....	.....	.....	90
No. 7	Range	35–43	37–46	40–60	37–43	35–60	56–66	55–65	55–65	56–63	55–65
	Average	39	44	47	41	43	61	59	61	60	60
No. 9	Range	27–103	43–74	43–73	75–174	43–174	38–56	37–50	42–67	38–50	37–67
	Average	75	60	60	108	76	46	43	55	48	48
No. 12	Range	240–600	360–600	360–600	300–486	240–600	180–240	180–240	180–240	180–240	180–240
	Average	384	480	492	408	441	225	200	216	216	214
No. 13	Range	39–90	25–101	42–59	25–67	25–101	85–110	65–92	70–95	90–96	65–110
	Average	84	55	58	53	62	99	83	80	93	89
No. 15	Range	.....	.....	.....	.....	......	.....	.....	.....	.....	......
	Average	.....	.....	.....	.....	720	.....	.....	.....	.....	540
Total Range		27–600	20–600	40–600	20–486	20–720	30–420	30–310	35–270	30–300	30–540
Grand Average		141	145	146	137	179	118	117	116	123	154
Percentage deviation from average						−89 +302					−81 +251

3. Many of the specimens were badly pitted, and in several instances these pits occurred at approximately similar locations on corresponding specimens. There is no assurance that these pits are always the result of the structural condition of the alloys; they may equally as well be due to the idiosyncrasies of the test such, for example, as local adherence of condensed spray.

Copper Sulfate Stain Test:

The copper sulfate stain test data shown in Table VI indicate the lack of agreement in quantitative results that characterizes this test. There is no evidence in the nature of the discrepancy of data to permit an explanation of causes. The most obvious possible causes of disagreement in data are: conditions of specimen surface, failure to note first appearance of copper deposit, and variation in temperature or composition of the sulfate solution. It is apparent that the test is highly sensitive to variable factors, from the fact that there is considerable variation in time required for the deposit to develop at different spots on the restricted area of a single specimen. There was universal agreement only in the facts that none of the specimens of Alloys A and B showed a deposit, and that all specimens of Alloys C and D showed the deposit although after varying periods of time.

Recommendations:

It is the intention of Subcommittee IV to continue with other experimental work and study for the purpose of developing a method of corrosion testing that will deserve consideration as a standard method. In the meantime, certain recommendations may be made, based upon the work done to date and applying strictly to the detailed methods described herein. They are as follows:

1. Neither the salt spray test nor the copper sulfate stain test may be considered as quantitative, nor its results reproducible in the same or different laboratories. The data from both of these tests are likely to be erratic. Hence, no important decision should be based on the data, concerning the suitability of an alloy for a given service or the quality of a particular sample of an alloy.

2. The boiling nitric acid test is capable of furnishing accurate, reproducible, quantitative data. This test may be used to determine the quality of alloys such as those tested and reported upon herein. It should be noted that within reasonably broad limits this may be true regardless of the service conditions to which the alloys are to be subjected.

Acknowledgments.—For valuable assistance in making possible the work recorded herein, a word of appreciation is extended to the following:

MATERIAL DONORS

Bethlehem Steel Co.
Carpenter Steel Co.
Republic Steel Corp.

TESTING PARTICIPANTS

- Allegheny Steel Co.
- Bell Telephone Laboratories, Inc.
- Bethlehem Steel Co.
- Bureau of Construction and Repair—Navy Dept.
- U. S. Bureau of Standards.
- Carpenter Steel Co.
- Crucible Steel Co.
- E. I. du Pont de Nemours and Co.
- Frigidaire Corp.
- The Midvale Co.
- Republic Steel Corp.
- Union Carbide and Carbon Research Labs.
- Westinghouse Electric and Mfg. Co.

COMMENTS BY DISCUSSERS

The report of Subcommittee IV was sent out in preliminary form to a number of interested metallurgists and engineers for comment. Discussion was submitted by the following:

- W. B. Arness, Alloy Research Corp.
- C. E. Margerum, Naval Gun Factory
- P. E. McKinney, Bethlehem Steel Co.
- R. F. Passano, American Rolling Mill Co.
- Sam Tour, Lucius Pitkin, Inc.

This discussion is presented in the form of abstracts giving only the salient features of each discussion. The several valuable suggestions made are being considered by the subcommittee in considering the next phase of the experimental program.

General Comments:

McKinney.—The results of the investigation tend to warrant the recommendations in the report, but no definite conclusions should be drawn as yet.

Passano.—The report implies too much, and the arrangement of the subject matter may lead to wrong interpretation through ambiguity. In general, corrosion testing should be conducted as nearly as possible under conditions similar to service conditions. The data should be presented in accordance with the principles formulated by the Society's Committee on Presentation of Data.[1]

Copper Sulfate Stain Test:

Tour.—More work should be done in standardizing the method of preparing the specimen surface, particularly just prior to the final step of polishing.

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[1] Manual on Presentation of Data, sponsored by Committee E-1 on Methods of Testing, presented at the Thirty-sixth Annual Meeting of the American Society for Testing Materials, June, 1933; see p. 451.

Boiling Nitric Acid Test:

Arness.—The report offers strong evidence that it is not difficult for several laboratories to obtain closely reproducible results with this test. However, it is quite likely that greater deviation in results would have been reported if the alloys tested had been heat treated differently.

It is believed that not more than one specimen should be tested in a flask, especially if the specimens show different corrosion rates, because of the influence exerted on the rate by corrosion products and deviation of the area-volume ratio.

It is considered unnecessary to conduct the test beyond the second or third 48-hr. period. Further delay in obtaining results may be avoided without affecting the accuracy of results by omitting the "aging" of the surface of the specimens.

McKinney.—Analysis of results on individual specimens indicates variation that can hardly justify the acceptance of average values. The nitric acid test, even though accurate, is too time-consuming for use as a practical control test.

Passano.—Certain data were omitted or accepted without regard for the principles of statistical analysis as described by Mr. W. A. Shewhart in "Economic Control of Quality of Manufactured Product." The data should be expressed as milligrams loss per 20 sq. cm. rather than as inches penetration per month.

Tour.—The analysis of the acid used by the various laboratories should be reported. More detailed description of the method of suspending specimens in the flask should be given.

The data indicate that testing need not be continued beyond the second period. It is suggested that the test periods be changed to an initial 12-hr. period and two 48-hr. periods, which would permit finishing the test in one week. This suggested change is based on the contention that the erratic variations in rate that may occur for various reasons probably take place during the first few hours of the test.

It is apparent from the data that Alloy B is more sensitive to the influence of acid concentration than the other alloys. It is suggested that this be studied.

Salt Spray Test:

Arness.—While the results obtained indicate that it is difficult to use the test as an accurate measure of corrosion resistance, the salt spray test has a legitimate though limited use for testing of the stainless alloys. It is contended that the test conditions described are too severe for the type and form (bar stock) of alloys used, and that it is probable that more consistent results would have been obtained if the solution concentration and time of test had been more closely suited to the alloys used. As described, the test conditions fail completely to simulate any known service conditions.

The pronounced effect of such variable factors as surface stability, supply of oxygen, form of specimen, presence of inclusions, local strains, etc., make the test a measure of the stability and uniformity of the surface film, rather than of the inherent resistance of the alloy. Experience has shown that sheet and strip specimens of even the 17 per cent chromium alloy are resistant to the test conditions described, but that specimens of bar stock of either the straight chromium or the chromium-nickel alloy will not consistently withstand the test.

Margerum.—The salt spray test included in this investigation was not the standard test used by the Navy under Navy Department Specifications 46-S-18.

The use of 20 per cent sodium chloride solution in the salt spray test was included as an alternate to 4 per cent sea salt brine, but it was not used in official tests as it was found unsuitable for the purpose. The Naval Gun Factory is in full concurrence with the unfavorable conclusions which appear in the subcommittee's report as to the salt spray testing with 20 per cent sodium chloride solution. The results gained by testing with 4 per cent sea salt solution are quite different.

McKinney.—The results of the salt spray test, while somewhat disappointing, will warrant further study and analysis. It is indicated that the surface of the specimens may have considerable influence on the results.

It is suggested that further tests be made as follows:

1. On specimens finished by standard emery sent out by the subcommittee.
2. On specimens of Alloy A annealed for four hours, and furnace cooled.
3. On specimens passivated by nitric acid.
4. On specimens exposed according to Navy specifications 46-S-18 for four periods of 24 hr. with examination and rating after each period.
5. With carefully kept temperature of the bath.

Tour.—The test results do not indicate that the complicated shape of specimen used is necessary. It is suggested that a specimen be used having a 60-deg. cone on a 0.75-in. cylindrical base.

The nozzle for producing the spray should be specified in more detail, and the liquid level should be kept constant in the cabinet. Detailed and constructive suggestions are given for the placing of the nozzle and for other important features influencing the amount and atomization of the mist or spray.

Other suggestions offered are that the baffle be placed at an angle of 45 deg., with no clearance at bottom, but 3 in. at top; that a glass wool oil strainer be used ahead of the air washing column; that glass be used for the shelves; and that the specimens be wrapped in cellophane before and after the test.

Detailed instructions should have been given on the type of tools, the tool condition, and the speed of machining the specimens. It is contended that these factors have more effect on the results than does the method of performing the final polishing steps.

Respectfully submitted on behalf of the subcommittee,

W. R. HUEY,
Chairman.

REPORT OF JOINT RESEARCH COMMITTEE

ON

EFFECT OF TEMPERATURE ON THE PROPERTIES OF METALS

PROGRESS REPORT TO THE SPONSOR SOCIETIES

The work of the Joint Research Committee proceeded uninterruptedly during the past year and three meetings were held; one in Atlantic City, N. J., in June, 1932, and two in New York City in December, 1932, and March, 1933, respectively.

Membership:

Two changes have occurred in the membership of the committee. Due to ill health, Mr. Clair Upthegrove found it necessary to withdraw from active work on the committee and the University of Michigan is now represented by Mr. A. E. White. Mr. H. W. Maack of the Crane Co. was appointed a member of the Joint Committee in place of Mr. L. W. Spring, deceased.

High-Temperature Test Methods:

Two proposed tentative methods of test covering high-temperature mechanical tests, appended hereto,[1] were prepared by Subcommittees C, D and E of Committee III on Technical Projects entitled, respectively, "Tentative Method of Test for Short-Time High-Temperature Tension Tests of Metallic Materials" and "Tentative Method of Test for Long-Time (Creep) High-Temperature Tension Tests of Metallic Materials."

These proposed methods which are submitted herewith to the sponsor societies for publication as tentative, have been approved by letter ballot of the Joint Committee, which consists of 14 members. The results of the letter ballot are given in the following table:

Items	Affirmative	Negative	Not Voting
I. PROPOSED TENTATIVE STANDARDS			
Method of Test for Short-Time High-Temperature Tension Tests of Metallic Materials	11	0	2
Method of Test for Long-Time (Creep) High-Temperature Tension Tests of Metallic Materials	11	0	2

The results of tests made on carbon steel by three members of Subcommittee D of Committee III under substantially the conditions outlined in the proposed Tentative Method of Test for Short-Time High-Temperature Tension Tests of Metallic Materials appear in Appendix I to this report. The results obtained at the three laboratories were consistent and are cited here in support of the short-time tension test. Other data in explanation of certain features of the code appear in Appendices II and III.

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[1] See pp. 996 and 1004.—ED.

Attention should be called to the fact that in the final preparation of the short-time high-temperature tension test method the cooperation of Committee B-4 on Electrical-Heating, Electrical-Resistance and Electric-Furnace Alloys of the American Society for Testing Materials was secured to the end that the requirements of both the Joint Committee and Committee B-4 might be met in a single method. The results of independent researches carried out by Committee B-4 and the experience of its membership were made available to the Joint Committee through Mr. F. E. Bash, secretary of Committee B-4.

Funds:

Expenditures made to date from funds contributed by the National Electric Light Association, Engineering Foundation, National Research Council, American Petroleum Institute, and the Alloy Casting Manufacturers Association amounted to about \$8500. Of this, about \$5000 was paid (over a period of 15 months) to the Battelle Memorial Institute and \$2000 (over a period of 12 months) to the University of Illinois for sponsored researches. A payment of about \$1500 was made to the Babcock & Wilcox Co. for special materials, and a small sum was also expended at the Carpenter Steel Co. for the rolling of steels for test.

The sums paid to these cooperators did not cover the entire costs to them of the materials or tests, the difference in each case representing part of their respective contributions to the work of the Joint Committee. Battelle Memorial Institute contributed approximately \$1000 of its own funds to committee work, and the Babcock & Wilcox Co. likewise expended an appreciable sum in excess of the \$1500 payment for the preparation of the special austenitic nickel-chromium steel melts required by the committee.

Acknowledgment should also be made to the Union Carbide and Carbon Research Laboratories, The International Nickel Co., Inc., and especially to The Superheater Co. for their contributions to the work of the committee through the machining of a considerable quantity of test materials.

The balance remaining from the original sum of some \$9200, together with an additional grant of \$3000 authorized for work of the committee during 1933 by the Engineering Foundation, will make it practicable to continue the sponsored researches relating to austenitic chromium-nickel stainless steels during the current calendar year and permit completion of the program originally outlined.

Committee Researches:

Due to the unsatisfactory economic conditions resulting in curtailment of many technical activities, the major progress in committee researches was made in those parts supported in part by direct contributions.

The results obtained in sponsored researches at the University of Illinois and the Battelle Memorial Institute, together with certain additional information obtained through cooperative committee work, will probably be reported completely during the latter part of the present calendar year. Comparisons will be available of cast and wrought 18 per cent chromium, 8 per cent nickel stainless steels with different carbon contents. Creep and fatigue characteristics of these materials will be given at temperatures up to 1200 F.

New Committee:

Problems relating to high-temperature applications of metals in oil refineries have been the basis of much interest and discussion during the past few years.

Acting upon suggestions from representatives of the American Association of Steel Manufacturers, and with the cooperation of the Refinery Division of the American Petroleum Institute, a new committee was formed within the Joint Committee during March, 1933. This committee, to be known as Committee V on Oil Refinery Problems (A.P.I. and A.A.S.M. cooperating) is comprised of three or four representatives from each of the three groups mentioned, and will undertake as its first work a survey of problems relating to still tube materials.

The present membership of Committee V is as follows:

NAME	REPRESENTING
H. W. Gillett, Battelle Memorial Institute	Joint Committee
C. E. MacQuigg, Union Carbide and Carbon Research Laboratories, Inc.	Joint Committee
H. J. French, The International Nickel Co., Inc.	Joint Committee
D. G. Brandt, H. L. Doherty and Co.	Am. Petroleum Inst.
M. S. Northrup, Standard Oil Development Co.	Am. Petroleum Inst.
T. D. Tifft, Sinclair Refining Co.	Am. Petroleum Inst.
G. M. Eaton, Spang, Chalfant and Co., Inc.	Am. Assn. Steel Mfrs.
R. L. Wilson, Timken Steel and Tube Co.	Am. Assn. Steel Mfrs.
E. C. Wright, National Tube Co.	Am. Assn. Steel Mfrs.
H. J. Kerr, Babcock & Wilcox Co.	Am. Assn. Steel Mfrs.

Mr. T. D. Tifft was elected permanent secretary of Committee V while Mr. H. J. French, the chairman of the Joint Committee, is acting as temporary chairman of this group.

Respectfully submitted on behalf of the Joint Committee,

H. J. FRENCH,
Chairman.

N. L. MOCHEL,
Secretary.

EDITORIAL NOTE

The proposed Tentative Methods of Test for Short-Time High-Temperature Tension Tests of Metallic Materials and for Long-Time (Creep) High-Temperature Tension Tests of Metallic Materials were accepted for publication as tentative and appear on pages 996 and 1004, respectively.

COOPERATIVE SHORT-TIME HIGH-TEMPERATURE TENSION TESTS OF CARBON STEEL K6

As a trial of the proposed Tentative Method of Test for Short-Time High-Temperature Tension Tests, cooperative work was undertaken by a special sub-subcommittee of Subcommittee D of Committee III on Technical Projects. This special committee consisted of Mr. H. F. Moore (University of Illinois), chairman; Mr. J. W. Bolton (Lunkenheimer Co.); and Mr. J. J. Kanter (Crane Co.). Each cooperator adhered to the requirements of the tentative code.

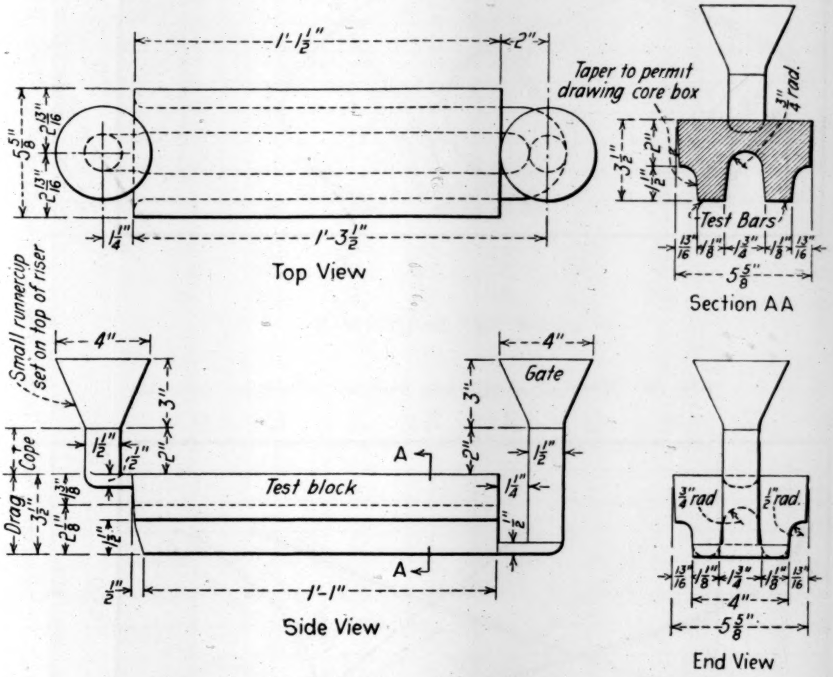
1'-1½"
2"
Taper to permit drawing core box
¾" rad.
5⅝"
2 13/16"
2 13/16"
3½"
2"
1½"
Test Bars
13/16"
1/8"
1¾"
1/8"
13/16"
5⅝"
Section AA
¼"
1'-3½"
Top View
Small runnercup set on top of riser
4"
3"
4"
Gate
Cope
Drag
1½"
½"
2"
3½"
2⅛"
1⅜"
Test block
A
A
1¼"
½"
1½"
½"
1'-1"
Side View
¾" rad
½" rad.
13/16"
1/8"
1¾"
1/8"
13/16"
4"
5⅝"
End View

FIG. 1.—Keel Block Test Specimen.

NOTE.—Casting Poured in Core Mold. One Core Box for Drag, One for Cope and One for Gate.

The material tested was an acid open-hearth carbon steel, designated material K6, containing 0.28 per cent carbon, 0.66 per cent manganese, 0.35 per cent silicon, 0.035 per cent phosphorus, and 0.040 per cent sulfur. It was from a split heat made by the American Steel Foundries, Indiana Harbor, from which both castings and ingots were

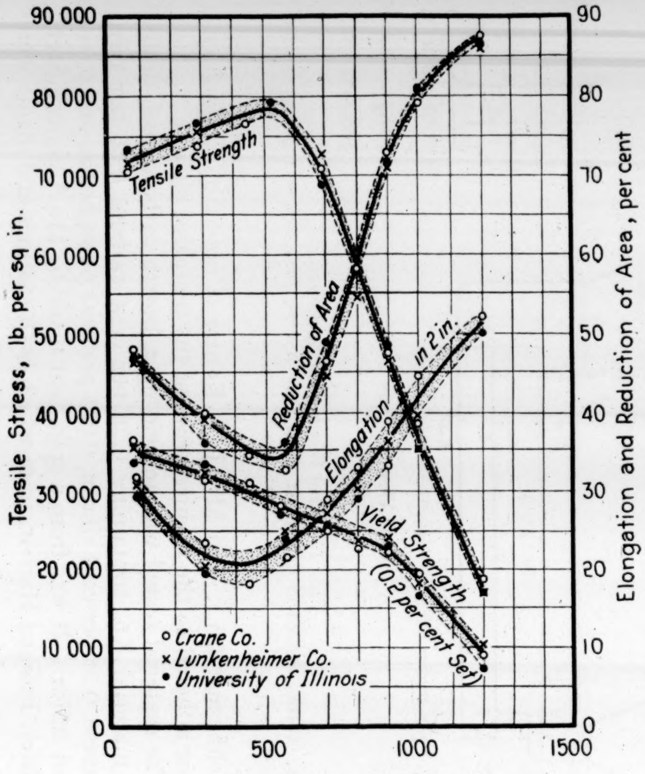

FIG. 2.—Results of Short-Time High-Temperature Tension Tests on Material K6a, annealed, cast.

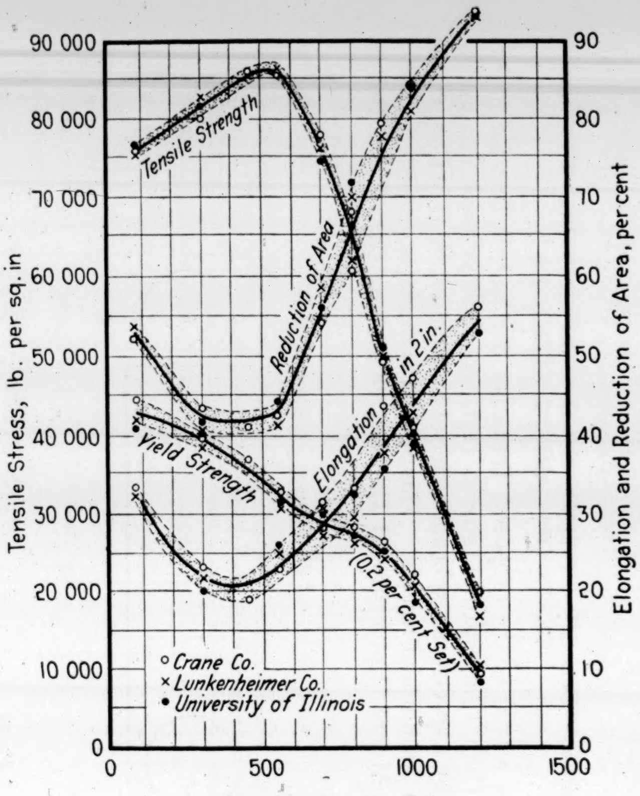

FIG. 3.—Results of Short-Time High-Temperature Tension Tests on Material K6b, normalized, cast.

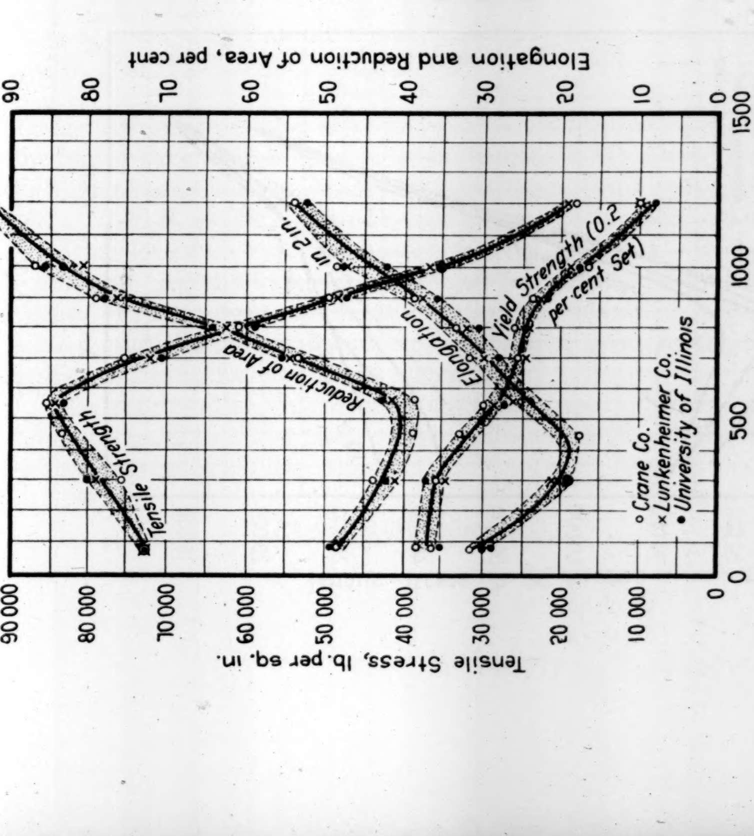

FIG. 4.—Results of Short-Time High-Temperature Tension Tests on Material K6c, annealed, rolled.

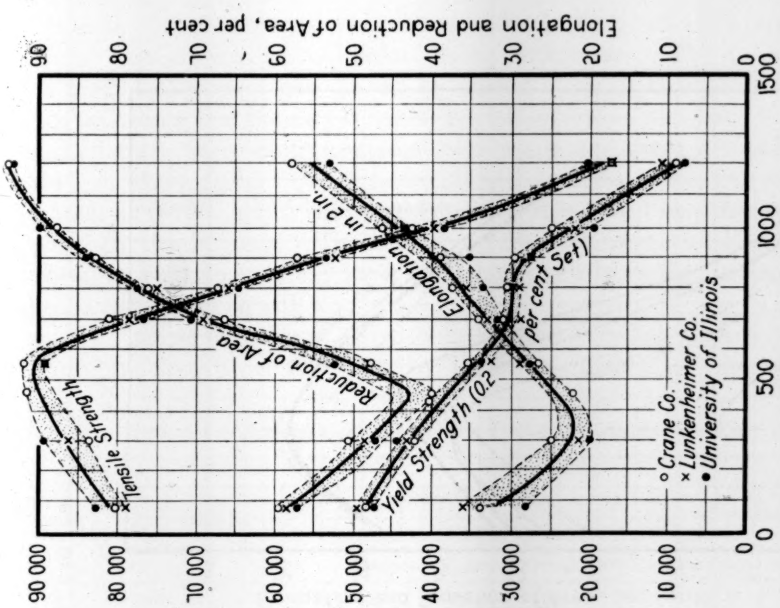

FIG. 5.—Results of Short-Time High-Temperature Tension Tests on Material K6d, normalized, rolled.

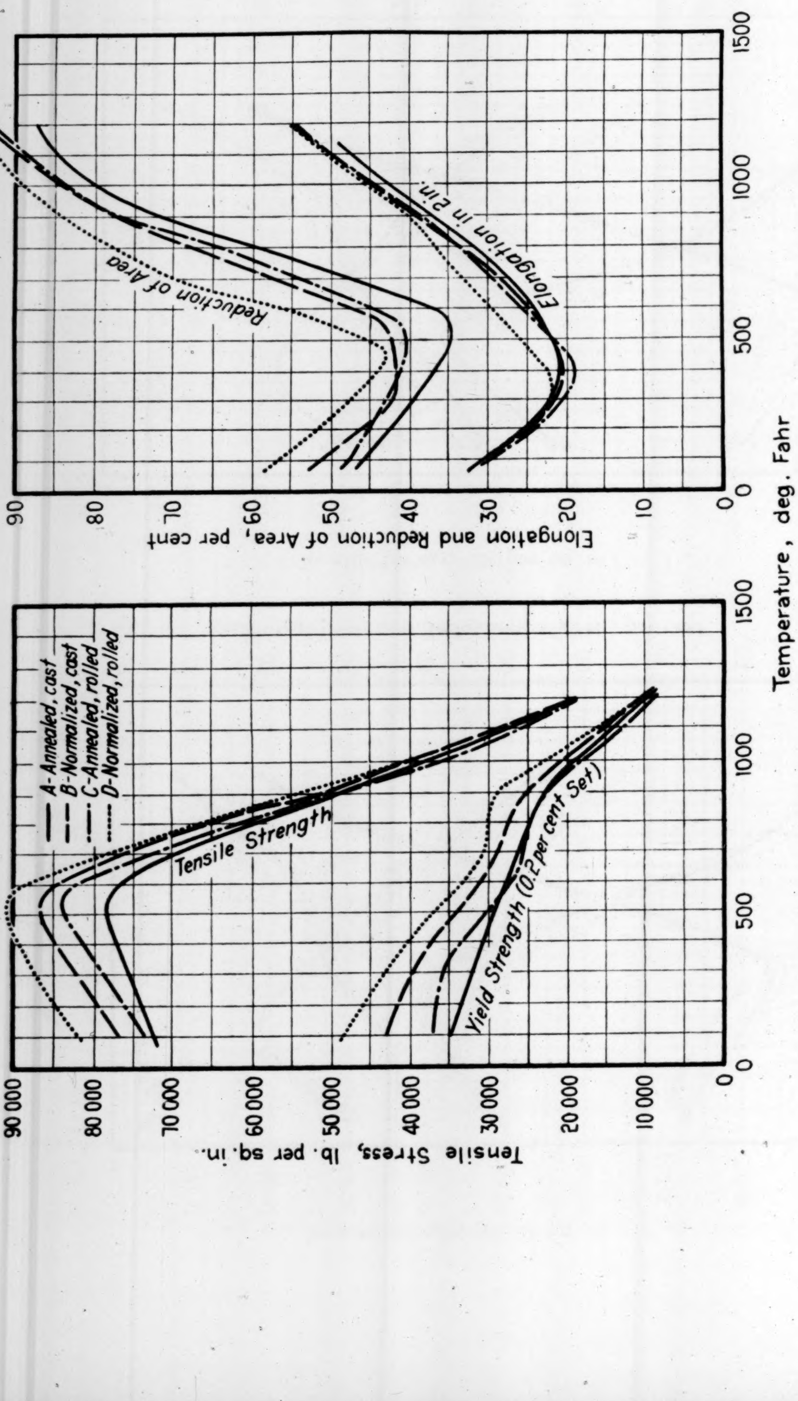

FIG. 6.—Summary of Results of Short-Time High-Temperature Tension Tests of Material K6.

obtained. The castings were poured as keel block test bars (see Fig. 1) and were allowed to cool before being shaken out. The keels from the test blocks were then cut off by means of an oxyacetylene torch, thus providing test pieces 13½ in. long, yielding two 6¾-in. bars or three 4¼-in. bars. Sixty-eight coupons were made and were divided into two lots of 34 each. One lot, designated material K6*a*, was heated to 1600 F. (870 C.) and held at this temperature for 1 hr., then slowly cooled in the furnace. The remaining 34 bars, material K6*b*, were heated to 1650 F. (900 C.) for 1 hr., then taken from the furnace and cooled separately in still air.

The ingots were 6¾ by 7¼ by 29 in. They were hot worked by the Columbia Tool Steel Co., first by hammer cogging to 4-in. square billets, and then by rolling to 1¼-in. squares and finally to ⅞-in. rounds. The forged bars were shipped in 36-in. lengths to Mr. David Zuege at the Sivyer Steel Castings Co. for heat treatment. One lot of 95 bars was held at 1600 F. (870 C.) for 1 hr. and allowed to furnace cool slowly. The other lot of 95 bars was heated to 1650 F. (900 C.) and cooled in still air. All the bars were examined for uniformity by hardness testing. Practically no hardness variation was found, as is shown in Table I, and the uniformity of the test results, given in the figures, testifies to the uniformity of the material.

TABLE I.—RESULTS OF HARDNESS TESTS ON MATERIAL K6.

Material	Condition	Brinell Hardness[a]			Rockwell Hardness[b] "B" scale, 100-kg. load, $\frac{1}{16}$-in. ball penetrator		
		Minimum	Maximum	Average	Minimum	Maximum	Average
K6a	Cast, annealed	143	146	145	67.2	68.5	67.9
K6b	Cast, normalized	153	158	155	74.2	75.2	74.7
K6c	Rolled, annealed	139	144	141	81.1	82.8	81.7
K6d	Rolled, normalized	156	163	160	89.5	90.8	90.2

[a] Brinell hardness tests were made on ends of unmachined bars.
[b] Rockwell hardness tests were made on machined specimens.

The results of the cooperative tests are presented in the accompanying Figs. 2 to 5 and the averages collected in Fig. 6; the legends for these figures are self-explanatory.

Respectfully submitted,

H. F. MOORE (*Chairman*)
J. W. BOLTON
J. J. KANTER
For Committee III on Technical Projects.

APPENDIX II

THE DETERMINATION AND SIGNIFICANCE OF "PROPORTIONAL LIMIT" AND "BREAKING STRENGTH" IN SHORT-TIME HIGH-TEMPERATURE TESTS

It will be noted that no mention of proportional limit or breaking strength is made in the proposed Tentative Method of Test for Short-Time High-Temperature Tension Tests of Metallic Materials[1] or in the report of cooperative work in Appendix I. The same special committee of three, however, studied these data also in its cooperative work on material K6, with the hope of developing information, if possible, that might be worked into a code for such tests as would enable different laboratories to obtain consistent results—whether or not the tests have engineering application. The cooperators accordingly laid down tentative requirements to which all adhered, and the work was performed by each laboratory with the greatest precision of which it was capable.

For lack of space, the details of the equipment and methods used are omitted since the results of the work on material K6 merely verify the conclusions to be drawn from previous work of the Joint Committee.

These conclusions, as drawn up by the special committee are given below.

Determination of Proportional Limit.—Either a high-temperature test or a test at room temperature is supposedly the determination of the stress at which the stress-strain diagram departs from a straight line. Unless the details of equipment, and of the process of plotting or tabulating results, are defined in very great detail this determination is an indefinite affair. It can be affected by:

1. Sensitivity and accuracy of testing machine.
2. Sensitivity and accuracy of extensometer.
3. Variation of time allowed for reading extensometer.
4. Scales used in plotting curve.
5. Technique and instruments used in drawing curve, or tolerance allowed if departure from proportionality is obtained from a table of values, differences and second differences.

The practical results of this uncertainty are seen in results of

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[1] See p. 996.—Ed.

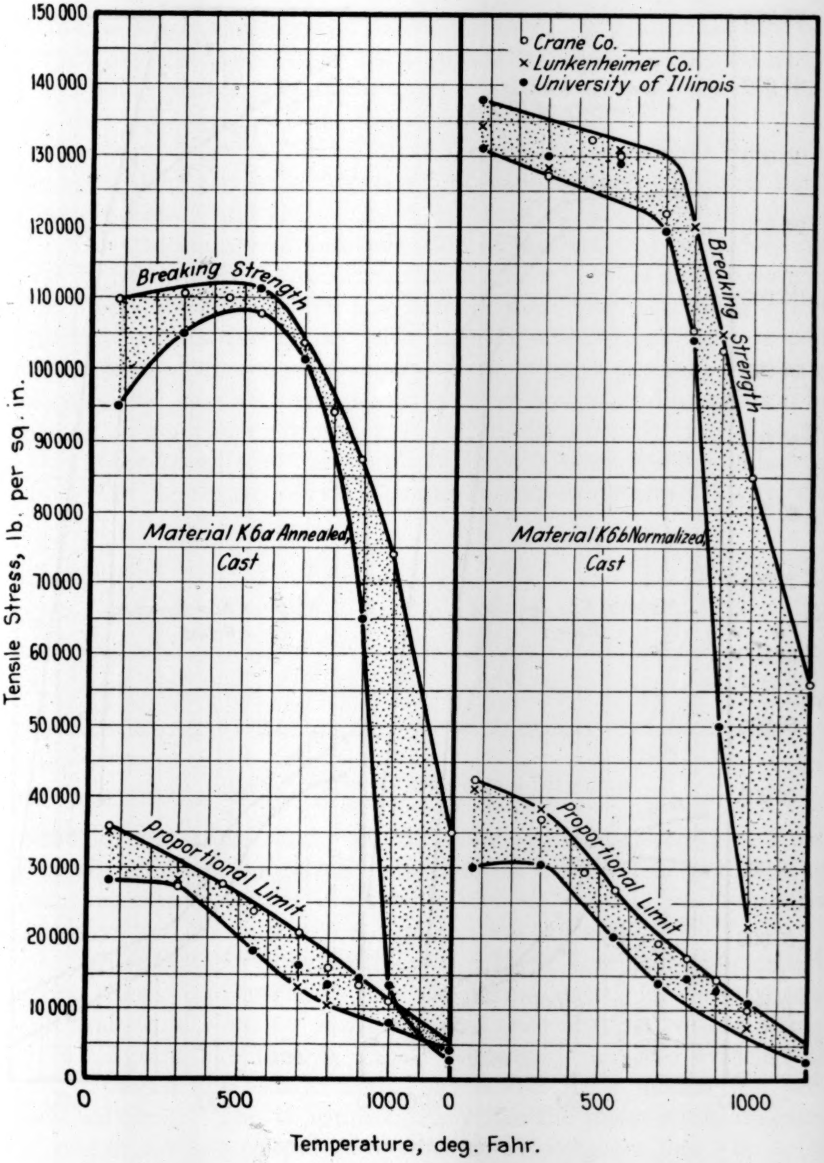

FIG. 1.—Proportional Limit and Breaking Strength in Short-Time High-Temperature Tests on Material K6.

the short-time high-temperature tests given in this report. There is a wider variation in results for proportional limit than for any other quantity, except, possibly breaking strength at high tempera-

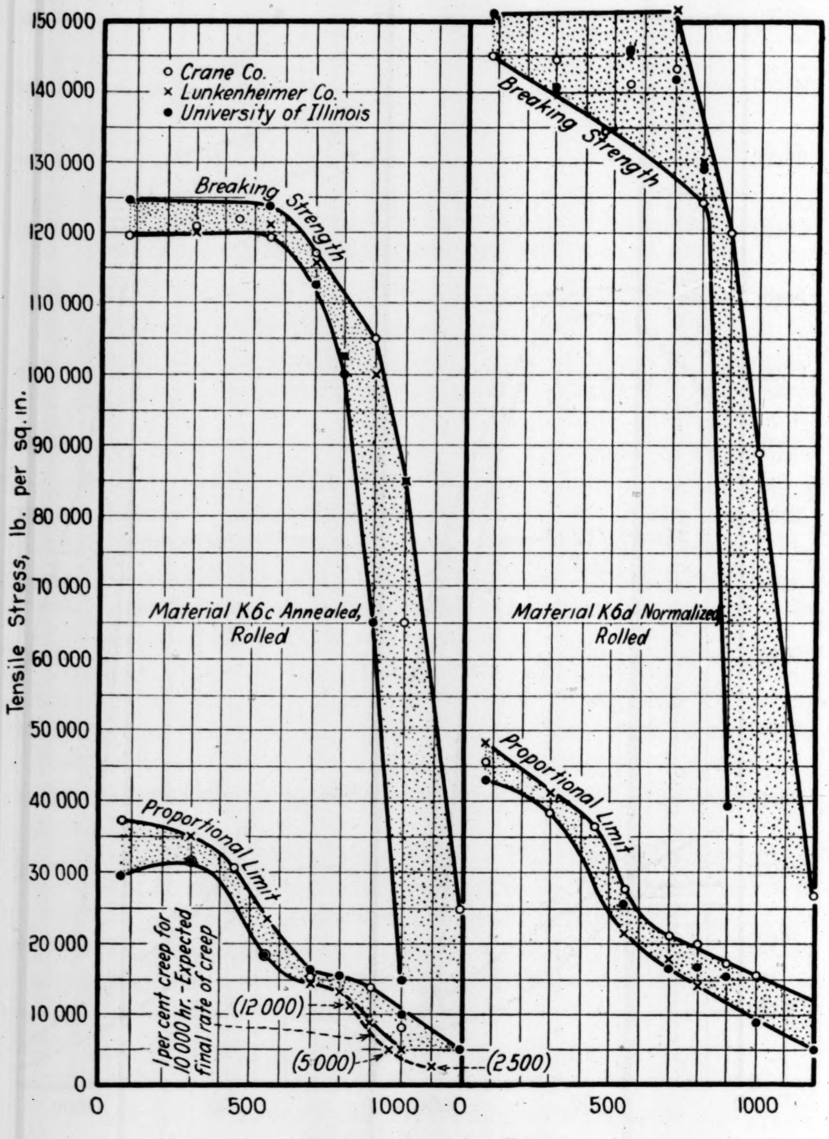

FIG. 2.—Proportional Limit and Breaking Strength in Short-Time High-Temperature Tests on Material K6.

tures. It is evident, moreover, that the determination of the stress at which a "stress-strain diagram departs from a straight line" is really the determination of an *arbitrary* value dependent on the technique used in testing and plotting graphs. The three laboratories cooperating in these tests used somewhat different procedure in determining proportional limit from a plotted stress-strain diagram, and this fact, together with the inherent uncertainty of locating the precise point where a "flat" curve merges into a straight line, goes far to explain the wide "scatter" of values for proportional limit, shown in Figs. 1 and 2.

The uncertainty of determination of proportional limit does not seem to be confined to uncertainties in the apparatus and technique. The steels themselves are not homogeneous but are made up of aggregate crystalline grains with various orientations with respect to direction of maximum resistance. It is quite possible that from the very first there is some departure from a straight-line relation on account of uneven deformation in individual crystals, and that the value reported as the "proportional limit" is merely the value for which the aggregate of such action becomes detectable with the particular apparatus used. Hooke's law of proportionality of stress to strain rests upon a purely experimental foundation; and it is by no means certain that it is a precise law, although it is a very close approximation for most rolled metals at low stresses.

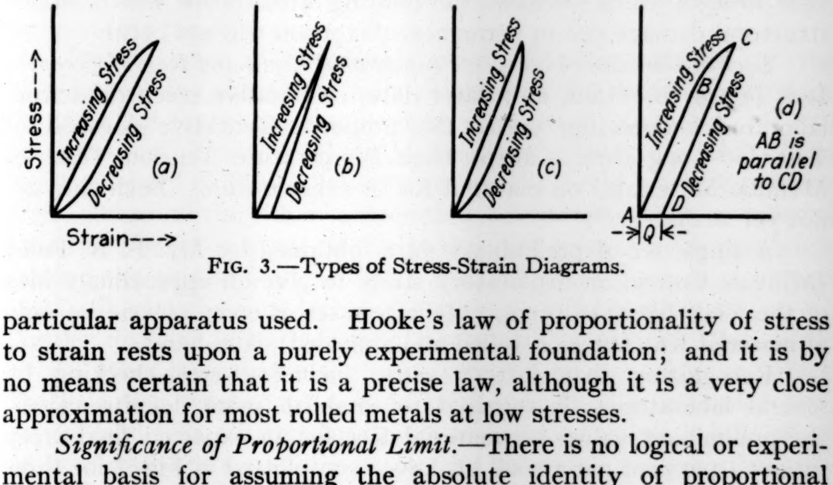

FIG. 3.—Types of Stress-Strain Diagrams.

Significance of Proportional Limit.—There is no logical or experimental basis for assuming the absolute identity of proportional limit and *elastic limit for first permanent set.* Material with a stress-strain diagram like that in Fig. 3 (*a*) would show no evidence of having passed the elastic limit, but would have passed the proportional limit. This is approximately like the stress-strain diagram for rubber for low stresses. A stress-strain diagram like Fig. 3 (*b*) would show that the metal had passed the elastic limit but not the proportional limit. None of the materials of construction known to the subcommittee give diagrams like this. Material with a stress-strain diagram like Fig. 3 (*c*) would seem to have passed neither the elastic limit nor the proportional limit and yet there would be a distinct loss of energy in the cycle of stress. A diagram like Fig. 3 (*c*) is rarely if ever obtained in tests of actual metals.

For a metal with a stress-strain diagram like that shown in Fig. 3 (*d*), the elastic limit and proportional limit would be identical, and most metals have stress-strain diagrams approximately like that in Fig. 3 (*d*). It is this fact which makes a proportional limit serve fairly well as an elastic limit.

Furthermore, the fact that a slight set, or a slight deviation from proportionality, has occurred does not, necessarily, indicate *structural damage* to the metal. It does not even indicate surely that millions of repetitions of this stress will cause damage to the material. It may, in some cases, indicate actual *improvement* of the strength of the metal.

It seems that even a very delicately determined proportional limit for a metal has little, if any, definite significance as an index of strength or weakness. This is in contrast to a fairly well defined *yield strength* which indicates the limiting stress below which serious structural damage due to permanent distortion will not occur.

Lack of Correlation between Proportional Limit and Rate of Creep.—It is hoped to obtain, at a later date, cooperative creep data from laboratories operating under the proposed Tentative Method of Test for Long-Time (Creep) High-Temperature Tension Tests of Metallic Materials,[1] on material K6 or other metals. Such data are not yet available.

A single set of preliminary data, obtained by Mr. F. B. Foley (Midvale Co.) in an exploratory study to give an approximate idea of the loads likely to produce definite rates of creep on one lot only of material K6 (Lot K6*c*, rolled and annealed), is in hand.

Recognizing that further work, including cross-checking by several laboratories, is required to establish more definite values, the preliminary values on material K6*c* for an expected final creep rate of 1 per cent per 10,000 hr. have been plotted in Fig. 2 for three temperatures. The preliminary values are based on 1000 to 1500-hr. tests at loads at which the final rate of flow was generally greater than 1 per cent per 10,000 hr., and on 600 to 750-hr. tests at which "no flow" was observed with the equipment used. The plotted values are therefore interpolations; they are, as well, based on too few tests for acceptance as other than exploratory values.

Nevertheless, even these tentative data indicate that for material K6*c* at temperatures above 800 F. some creep can be detected at stresses lower than any proportional limits determined in the short-time tests. This result is in line with results reported by various other investigators.[1] It seems that at the present time there is no direct experimental evidence which indicates that a proportional limit determined in a short-time test is a reliable index for creep strength of a metal at high temperature.

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[1] See p. 1004.—ED.

In general, small grain size in a metal adds to the resistance to slip at room temperature. At high temperatures there is some evidence that for some metals at least large grain size is of advantage in resisting creep.[2] The dividing line of temperature will of course vary with the type of material. It is not at all sure that the slip detected by a short-time test and the creep detected by a long-time test involve the same mechanism of crystalline distortion.

Determination of Proportional Limit Not Recommended.—In view of the uncertainties of determination of proportional limit, and of the uncertainties of significance and identity of action by the intra-crystalline slip and short-time tests and the phenomenon of creep in long-time tests, the determination of proportional limit has not been included in the tentative method for short-time high-temperature tension tests.

Determination of Breaking Strength.—An examination of the test data of the short-time tests of material K6 shows a very wide "scatter" of results for the breaking strength of the metal. It will be noted that, especially at the higher temperatures, the results from the University of Illinois laboratories are distinctly lower than those from either of the other cooperating laboratories. It is believed that this scatter of results is due to the very great difficulty of determining the precise load at which fracture takes place in a tension test. It may be noted that the tests at Illinois were run on an Amsler machine whose weighing mechanism is self-indicating, while at the other laboratories the tests were run on a machine on which the load was weighed by a hand-balance beam. In a tension test, as the load falls off from maximum to breaking value, it falls off at an accelerated rate, and it is practically impossible to keep a balance-beam in anywhere near accurate balance, unless the speed of pulling is so slow that at high temperatures the effects of actual creep of the metal would begin to be evident. It is a little less difficult to determine breaking load on a self-indicating machine, but, both on the Amsler machine and the Riehle and Olsen machines, the inertia of weighing mechanism introduces errors into the determination of breaking strength.

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[1] J. J. Kanter and L. W. Spring, "Some Long-Time Tension Tests of Steels at Elevated Temperatures," *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 115 (1930).

[2] *Ibid.*, p. 117.

In tests at high temperatures the difficulty of determining breaking strength is markedly increased. The actual point of fracture is less certain and at best the value reported for breaking load is the operator's estimate of the load at the instant of fracture. In view of the practical impossibility of the accurate determination of the breaking load, determination of breaking strength has also been omitted from the tentative method for short-time high-temperature tension tests.

Respectfully submitted,

H. F. MOORE (*Chairman*)
J. W. BOLTON
J. J. KANTER
For Committee III on Technical Projects.

APPENDIX III

THE SIGNIFICANCE OF THE RESULTS OF SHORT-TIME HIGH-TEMPERATURE TENSION TESTS

Considering the significance of short-time, high-temperature tension tests, first from the negative side, there has as yet been developed no correlation between these results and the phenomenon of slow creep at high temperatures. This does not mean that further research cannot possibly develop such correlation, but merely that no such correlation has yet been developed.

There is no evidence of correlation between short-time high-temperature tests and fatigue tests. Whether the rough correlation between fatigue strength and tensile strength, which is evident in most room-temperature tests, holds at the higher temperatures has not as yet been determined.

Turning to the positive side of this question of significance of short-time test results, it appears that the results of short-time high-temperature tension tests *are* significant for metal exposed to occasional short periods of high temperature,—periods so short that the phenomena of creep are not very important, and the load is repeated at most a few thousand times, so that the question of fatigue strength will not be of major importance. As an index of resistance to permanent distortion under such occasional short-time loads, the yield strength appears to be a reasonably satisfactory index, while elongation and reduction of area may be used as indexes of ductility under such loading conditions.

In general, short-time high-temperature tests have a narrower field of usefulness than do short-time tests at room temperature. Room temperature tests give data of significance both for occasional short-time loads and for continued loads since, except in the case of very soft metals, creep at room temperatures seems to be not appreciable. Short-time high-temperature test results seem to be significant under conditions of occasional loading where the cycles of load are comparatively few in number and the total duration of the load period is only a few hundred hours.

Respectfully submitted,

H. F. Moore (*Chairman*)
J. W. Bolton
J. J. Kanter
For Committee III on Technical Projects.

REPORT OF COMMITTEE B-2

ON

NON-FERROUS METALS AND ALLOYS

Committee B-2 has not held a meeting since its meeting during the 1932 annual meeting of the Society. A meeting of the committee will be held prior to the presentation of this report to the Society when the report will be reviewed and other matters considered.

Recommendations Affecting Standards

The recommendations of the committee affecting standards are presented first in summarized form together with an analysis of the letter ballot on each item. They are then referred to in detail under activities of subcommittees, being grouped for convenience in the order of the respective subcommittee directly responsible for them.

I. Proposed Revision of Standards.—The committee recommends for immediate adoption a revision of the Standard Specifications for Slab Zinc (Spelter) (B 6 – 18), proposed by Subcommittee I, and accordingly asks for the necessary nine-tenths vote at the annual meeting in order that this revision may be submitted to letter ballot of the Society for immediate adoption.

The committee also recommends changes of an editorial nature, proposed by Subcommittee VII, in the following four standards:

Methods of Chemical Analysis of Manganese Bronze (B 27 – 19)
Methods of Chemical Analysis of Gun Metal (B 28 – 19)
Methods of Chemical Analysis of Brass Ingots and Sand Castings (B 45 – 27)
Methods of Chemical Analysis of Bronze Bearing Metal (B 46 – 27)

II. Adoption of Tentative Standards as Standard.—The committee recommends that the following two tentative standards be adopted as standard:

Tentative Specifications for Fire-Refined Copper Other than Lake (B 72 – 32 T), recommended by Subcommittee I;

Tentative Methods of Chemical Analysis of Silver Solders (B 81 – 31 T), recommended by Subcommittee VII.

The recommendations appearing in this report have been submitted to letter ballot of the committee, which consists of 99 members, with the following results:

Items	Affirmative	Negative	Not Voting
I. PROPOSED REVISION OF STANDARDS			
Specifications for Slab Zinc (Spelter) (B 6 – 18), immediate adoption	34	0	24
Methods of Chemical Analysis of Manganese Bronze (B 27 – 19), editorial revision	35	0	23
Methods of Chemical Analysis of Gun Metal (B 28 – 19), editorial revision	34	0	24
Methods of Chemical Analysis of Brass Ingots and Sand Castings (B 45 – 27), editorial revision	36	0	22
Methods of Chemical Analysis of Bronze Bearing Metal (B 46 – 27), editorial revision	35	0	23
II. ADOPTION OF TENTATIVE STANDARDS AS STANDARD			
Specifications for Fire-Refined Copper Other than Lake (B 72 – 32 T)	35	0	23
Methods of Chemical Analysis of Silver Solders (B 81 – 31 T)	33	0	25

ACTIVITIES OF SUBCOMMITTEES

Subcommittee I on Pure Metals in Ingot Form (W. H. Bassett, chairman).—Subsequent to the 1932 annual meeting, as mentioned in the annual report last year,[1] on the recommendation of this subcommittee Committee B-2 presented to the Society through Committee E-10 on Standards a revision of the Tentative Specifications for Fire-Refined Copper Other than Lake (B 72 – 28 T). The revised specifications were accepted for publication as tentative[2] by Committee E-10 at a meeting held on August 11, 1932, and appear in the 1932 *Proceedings*.[3] The subcommittee now recommends that these specifications as revised last year be adopted as standard.

In 1932 the subcommittee approved for publication as information requirements for a special high-grade zinc usually known as 99.99 per cent, suitable for certain die casting and other uses for addition to the Standard Specifications for Slab Zinc (Spelter) (B 6 – 18).[4] The committee now recommends that the following requirements for the special high-grade zinc be adopted immediately and incorporated in Section 4 of the present standard specifications:

(*1a*) *Special High Grade.*—The slab zinc (spelter) shall not contain over:
0.010 per cent lead.
0.005 per cent iron.
0.005 per cent cadmium.
It shall be free from aluminum.
The sum of the lead, iron and cadmium shall not exceed 0.010 per cent.

Subcommittee IV on White Metals—Tin, Lead and Zinc (G. H. Clamer, chairman).—There is being presented at this annual meeting a report of an investigation by Mr. John N. Kenyon on "The Effect of the Addition of Lead on the Hardness of Certain Tin-Base Bearing Alloys at Elevated Temperatures."[1] This paper contains direct evidence on matters about which there have been pronounced differences of opinion and indicates that the addition of lead improves the physical properties of certain interesting alloys which may be much more cheaply produced than alloys of highly restricted lead content. In view of these findings, the subcommittee proposes to give consideration to amending the Standard Specifications for White Metal Bearing Alloys (Known Commercially as "Babbitt Metal") (B 23 – 26)[2] as far as the chemical compositions of alloys Nos. 1, 2 and 3 are concerned.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 198 (1932).

[2] In submitting these revised tentative specifications to Committee E-10 on Standards, the committee reported results of the letter ballot vote as follows: Of a total membership of 97, 84 members returned their ballots, of whom 79 voted affirmatively and none negatively.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 663 (1932); also 1932 Book of A.S.T.M. Tentative Standards, p. 223.

[4] 1930 Book of A.S.T.M. Standards, Part I, p. 582.

Subcommittee VII on Methods of Chemical Analysis (H. V. Churchill, chairman).—Subcommittee VII has had a very active year. It has voted to eliminate the requirement that certain electrolytic analyses be conducted at 10 volts, which involves changes of an editorial nature in the following four standard specifications:

Standard Methods of Chemical Analysis of Manganese Bronze (B 27 – 19).[3]—Under Determination of Lead by the Electrolytic Method, change the eleventh sentence under Method to read as follows, by the addition of the italicized words and figures and the omission of those in brackets:

> For each solution use a current *density* of 1.25 to 1.5 amp. [at 10 v. continued] *per sq. dm.* (*11.25 to 13.5 amp. per sq. ft.*), for [about] 1 hr.

Under Determination of Copper and Lead Simultaneously by the Electrolytic Method, change the seventh sentence under Method to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

> Cover with a pair of split watch glasses and electrolyze. [using] *For each solution use* a current *density* of from 3 to 5 amp. [at approximately 10 v. for each solution] *per sq. dm.* (*27 to 45 amp. per sq. ft.*).

Standard Methods of Chemical Analysis of Gun Metal (*B 28 – 19*).[4]—Make the same editorial change in these methods under Determination of Lead by the Electrolytic Method in the eleventh sentence under Method as is recommended in the Standard Methods of Chemical Analysis of Manganese Bronze (B 27 – 19) above.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part II, p. 430 (1933).

[2] 1930 Book of A.S.T.M. Standards, Part I, p. 707.

[3] *Ibid.*, p. 813.

[4] *Ibid.*, p. 824.

Standard Methods of Chemical Analysis of Brass Ingots and Sand Castings (B 45 – 27).[1]—Under Determination of Copper by the Electrolytic Method, change the eighth sentence under Method to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

> For each solution use a current *density* over night of 0.5 amp. [at approximately 10 v.] *per sq. dm. (4.5 amp. per sq. ft.)*, or [else] use a current *density* of 4 amp. [at approximately 10 v. continued] *per sq. dm. (36 amp. per sq. ft.)* for [about] 2½ hr.

Make a similar editorial change in these methods under Determination of Lead by the Electrolytic Method in the eleventh sentence under Method and under Determination of Copper and Lead Simultaneously by the Electrolytic Method in the seventh sentence under Method as is recommended in the Standard Methods of Chemical Analysis of Manganese Bronze (B 27 – 19), above.

In addition to these changes, the subcommittee has prepared for addition to these methods a procedure for the determination of phosphorus. This procedure for determining phosphorus will be presented to Committee B-2 at a meeting to be held during this annual meeting, and if approved by the committee the proposed method will be submitted to the Society during the summer through Committee E-10 on Standards as a tentative revision of the Standard Methods B 45.[2]

Standard Methods of Chemical Analysis of Bronze Bearing Metal (B 46 – 27).[3]—Under Determination of Lead by the Electrolytic Method, change the ninth sentence under Method to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

> For each solution use a current *density* of 2 amp. [at 10 v. continued] *per sq. dm. (18 amp. per sq. ft.)* for [about] 2 hr.

The committee recommends a minor modification in the Determination of Nickel by the Dimethylglyoxime Method. The method as written apparently assumes that the sample to be analyzed for copper is dissolved in the acid mixture usually used for the purpose and electrolyzed without removing tin. It is accordingly recommended that the first sentence under Method be changed from its present form: namely,

> In a 200-cc. electrolytic beaker, dissolve a 1-g. sample exactly as in the "Determination of Copper by the Electrolytic Method" and remove the copper by electrolysis.

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 837.

[2] The method was accepted for publication as tentative and appears on p. 638. See Editorial Note, p. 231.—ED.

[3] *Ibid.*, p. 851.

to read as follows:

> In a 150-cc. beaker, dissolve a 1-g. sample of the bronze in 10 cc. of HNO_3 (sp. gr. 1.42) and remove tin and copper exactly as described in the Determination of Copper by the Electrolytic Method.

The subcommittee has also approved the adoption as standard of the Tentative Methods of Chemical Analysis of Silver Solders (B 81 - 31 T).[1]

The subcommittee, after attempting to secure agreement on the Tentative Methods of Chemical Analysis of Aluminum and Light Aluminum Alloys (B 40 - 28 T),[2] has voted to replace them with procedures of analysis, the preparation of which has just been completed and approved by the subcommittee. These improved methods, which shorten the methods of analysis, will be presented to Committee B-2 at a meeting to be held during this annual meeting, and if approved by the committee will be submitted to the Society during the summer through Committee E-10 on Standards for publication as tentative.[3]

This report has been submitted to letter ballot of the committee which consists of 99 members; 58 members returned their ballots, of whom 52 have voted affirmatively and none negatively.

Respectfully submitted on behalf of the committee,

WILLIAM CAMPBELL,
Chairman.

E. E. THUM,
Secretary.

EDITORIAL NOTE

The revision proposed for immediate adoption in the Standard Specifications for Slab Zinc (Spelter) was approved at the annual meeting by a unanimous vote and subsequently adopted by letter ballot of the Society on September 1, 1933. The specifications in their revised form appear in the 1933 Book of A.S.T.M. Standards, Part I, page 858.

The editorial revisions of the Standard Methods of Chemical Analysis of Manganese Bronze, of Gun Metal, of Brass Ingots and Sand Castings and of Bronze Bearing Metal were approved.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 722 (1931); also 1932 Book of A.S.T.M. Tentative Standards, p. 325.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 782 (1928); also 1932 Book of A.S.T.M. Tentative Standards, p. 309.

[3] The revised methods were accepted for publication as tentative and appear on p. 620. See Editorial Note, p 231.—ED.

The Tentative Specifications for Fire-Refined Copper Other than Lake and the Tentative Methods of Chemical Analysis of Silver Solders were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1933, and appear in the 1933 Book of A.S.T.M. Standards, Part I, pages 577 and 831, respectively.

Recommendations to Committee E-10 on Standards.—Revisions of the Tentative Methods of Chemical Analysis of Aluminum and Light Aluminum Alloys, referred to in the report, were accepted on September 2, 1933, by Committee E-10 on Standards. The methods in their revised form appear on page 620.

A revision of the Standard Methods of Chemical Analysis of Brass Ingots and Sand Castings in the form of a procedure for the determination of phosphorus, to be subsequently incorporated in the standard methods, was accepted for publication as a separate tentative method on September 2, 1933, by Committee E-10 on Standards and appears on page 638.

REPORT OF COMMITTEE B-3

ON

CORROSION OF NON-FERROUS METALS AND ALLOYS

Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys has been active during the past year through its Subcommittees VI, VII and VIII in carrying forward the extensive programs of corrosion tests in the field.

The 1932 report[1] of the committee gave complete information with regard to the materials that are being studied by these subcommittees in their field tests and described in detail the program of field tests planned for each subcommittee, which include atmospheric corrosion, corrosion in liquids and corrosion due to galvanic and electrolytic action.

Subcommittee VI on Atmospheric Corrosion (W. H. Finkeldey, chairman).—Subcommittee VI is presenting in its report appended hereto detailed results on twenty-four non-ferrous metals and alloys after an exposure of approximately one year at the nine different test locations representing as many types of atmospheric conditions. The data show the changes in weight, tensile strength and elongation that the materials have undergone after one year's exposure. The report also includes the results of a visual examination of the specimens made to determine as nearly as practicable the amount and character of the corrosion product films on the surfaces of the specimens. A summary of the meteorological data at the test locations during the exposure period is also reported.

Subcommittee VII on Corrosion in Liquids (R. J. McKay, chairman).—Progress has been made in the field test program of Subcommittee VII which comprises studies of the resistance of representative non-ferrous metals and alloys to a few common solutions which include sulfuric acid, hydrochloric acid, caustic soda and common salt solution. A detailed description of the liquid corrosion test program appeared in the 1932 report.[2] Approximately one quarter of the whole program of tests of resistance to sulfuric acid has been completed. The balance of the testing of resistance to sulfuric acid is going ahead.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 201 (1932).

[2] *Ibid.*, p. 243.

Subcommittee VII has been hampered by the current business depression in carrying forward the tests of resistance to hydrochloric acid, salt brines and caustic soda. On account of the closing of certain industrial plants and changes in personnel, it may be necessary for the subcommittee to make new arrangements so that these branches of the work can go forward.

Subcommittee VIII on Galvanic and Electrolytic Corrosion (C. L. Hippensteel, chairman).—The corrosion testing program of Subcommittee VIII includes outdoor exposure tests of galvanic couples of the metals in common use and complete immersion couple tests of certain metals and alloys in hot water, brine, alkali and acid at nine test locations. The specimens described in the 1932 report[1] have been installed at the nine test locations and the one-year exposure samples have been returned from the exposure locations and examination has been partially completed. It is expected that the 1934 report of the committee will contain detailed data showing the results of the first period of exposure of the galvanic and electrolytic couples used by Subcommittee VIII.

This report has been submitted to letter ballot of the committee, which consists of 43 members; 36 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

T. S. FULLER,
Chairman.

SAM TOUR,
Secretary.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, pp. 215, 248 (1932).

REPORT OF SUBCOMMITTEE VI ON ATMOSPHERIC CORROSION OF NON-FERROUS METALS AND ALLOYS

This report presents the results of the atmospheric corrosion tests on twenty-four non-ferrous metals and alloys after an exposure of approximately one year at each of nine test locations. The amount of corrosion was measured by the following:

1. Determining the change in weight on duplicate 9 by 12-in. plate specimens;
2. Tension tests to find the change in tensile strength and percentage elongation; and
3. A visual examination of the 9 by 12-in. plates from each of the nine test locations to determine the amount and character of the corrosion product films on the surface of the specimens.

An extensive description of the metals and alloys in this test, including information with regard to physical properties, chemical composition, process of manufacture, rolling treatment, and metallographic structure of the materials appears in the 1932 report of Committee B-3, which also gives the details of the plan for exposing and testing the materials.[1]

DISCUSSION OF CHANGES IN WEIGHT TESTS

The 9 by 12-in. plates were weighed just as they were taken from the test racks without attempting to remove any accumulations of corrosion products either by brushing or chemical cleaning. The weight determinations were made by the Division of Metallurgy of the U. S. Bureau of Standards, using a special size analytical balance sensitive to 0.001 g., although weights of the plates are reported only to 0.01 g. The agreement between duplicate plates was very good considering the opportunity for corrosion products to be lost from the plates in handling and jarring them in transit from the test locations and upon their arrival at the Bureau of Standards.

Since no standard units have been adopted by the subcommittee for reporting weight changes, it was decided to report only the total weight change in grams for each 9 by 12-in. plate, prefixed by a positive or negative sign to indicate a gain or loss. These weight changes can readily be converted to grams per square centimeter per year, average penetration in inches per year or any unit desired by reference to the tabulation of exposure periods, critical data and conversion formulas in Table I. The densities of the metals and alloys under test are given in Table II.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 201 (1932).

However, since all the exposure plates are of the same size and thickness within close limits, it is possible in the case of any one material to compare the weight changes at one location with the weight changes at any other location. Also, where the differences in the densities of the test materials are not too great, similar comparisons can even be made between different metals and alloys without much sacrifice in accuracy. In many cases the weight changes are too small to be of any significance; nevertheless, useful comparisons can be made in some instances.

TABLE I.—LENGTH OF EXPOSURE PERIODS AT VARIOUS TEST LOCATIONS.

TEST LOCATION	EXPOSURE PERIOD	ELAPSED TIME	
		DAYS	YEARS
No. 1. Brunot Island, Pittsburgh, Pa.	July 8, 1931 to Sept. 8, 1932	428	1.17
No. 2. Altoona, Pa.	July 9, 1931 to Sept. 19, 1932	438	1.20
No. 3. State College, Pa.	July 9, 1931 to Sept. 3, 1932	422	1.15
No. 4. New York City	June 2, 1931 to Sept. 7, 1932	456	1.25
No. 5. Sandy Hook, N. J.	June 8, 1931 to Sept. 20, 1932	470	1.29
No. 6. Rochester, N. Y.	July 11, 1931 to Sept. 3, 1932 (tension)	420	1.15
	Dec. 12, 1931 to Sept. 2, 1932 (plates)	265	0.73
No. 7. Key West, Fla.	July 16, 1931 to Sept. 4, 1932	416	1.14
No. 8. Phoenix, Ariz.	Aug. 22, 1931 to Sept. 9, 1932	389	1.06
No. 9. La Jolla (San Diego), Calif.	Sept. 1, 1931 to Sept. 15, 1932	380	1.04

CRITICAL DATA

Size of plate: 9 by 12 by 0.035 in. thick (22.86 by 30.48 by 0.089 dm.)

Exposed area of plate: 217.5 sq. in. (1403 sq. cm.); 1.51 sq. ft. (14.03 sq. dm.)

$$\text{Change in weight, mg. per sq. cm. per year} = \frac{\text{Avg. wt. change in milligrams}}{1403 \times \text{elapsed time in years}}$$

$$\text{Change in weight, oz. per sq. ft. per year} = \frac{\text{Avg. wt. change in grams}}{42.8 \times \text{elapsed time in years}}$$

$$\text{Average penetration, in. per year} = \frac{0.393 \times \text{Avg. wt. change in grams per sq. cm. per year}}{\text{Density (grams per cu. cm.)}}$$

As would be expected in view of the short exposure period, corrosion has not progressed far enough in most cases to eliminate the initial gain in weight which may have occurred with all the specimens, irrespective of composition. These gains are due, of course, to the formation of corrosion product films plus accumulations of soot and dust. However, at the more corrosive industrial locations, New York City, Pittsburgh and Altoona, Pa., the attack has been so severe that the early initial gains have been more than offset later by decided losses for many of the materials. At La Jolla, Calif., the heavy accumulations of corrosion products appear as unusually large "gains" in weight and are indicative of the severity of the attack in this peculiarly corrosive atmosphere.

Figure 1 shows the general form of the curve of weight changes plotted against time exposed to the atmosphere.

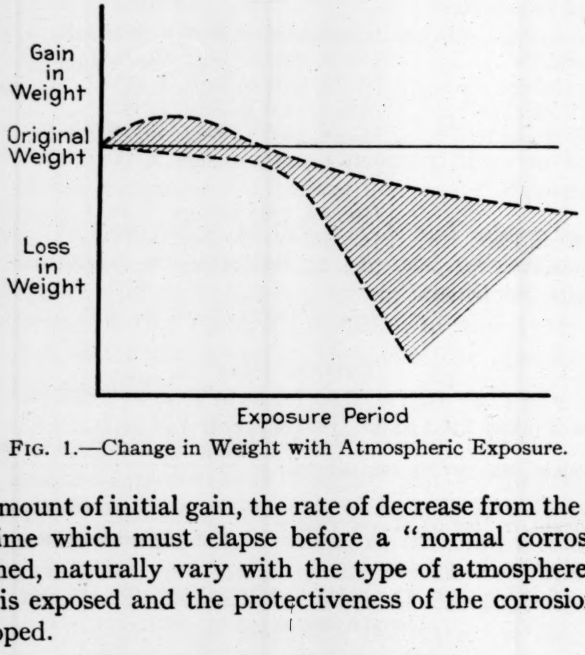

FIG. 1.—Change in Weight with Atmospheric Exposure.

The amount of initial gain, the rate of decrease from the maximum and the time which must elapse before a "normal corrosion rate" is established, naturally vary with the type of atmosphere in which the metal is exposed and the protectiveness of the corrosion product film developed.

DISCUSSION OF TENSION TESTS

The tension specimens, cut from the same stock of sheet metal as the 9 by 12-in. plates, were exposed simultaneously with the plate specimens in every case with the exception of the Rochester location. Here the plate specimens were exposed several months later owing to the theft of the entire first set of plates from the racks. Six specimens of each metal and alloy from each location were tested and their ultimate tensile strengths and percentage elongations averaged after omitting any results from specimens which broke outside the gage marks. The tensile strength, determined from the breaking loads of the corroded specimens, was calculated on the basis of the original areas of the test specimens before exposure, since obviously it would be impossible to determine accurately these areas on the corroded sections. The corroded specimens of each material were pulled on the same machines and under the same test conditions as were used in determining the original tensile properties of that material before exposure.

TABLE II.—TABLE OF DENSITIES OF NON-FERROUS METALS AND ALLOYS IN ATMOSPHERIC CORROSION TESTS.

IDENTIFICATION LETTER	MATERIAL	DENSITY, G. PER CU. CM.
A	Commercial Copper (Tough Pitch)	8.90
B	Commercial Copper (Phosphorized)	8.93
C	Cu-Si-Mn Alloy (96 Cu, 3 Si, 1 Mn)	8.54
D	Tin Bronze (92 Cu, 8 Sn)	8.82
F	Aluminum Bronze (92 Cu, 8 Al)	7.79
G	Commercial Aluminum (99+ per cent Pure)	2.71
I	Al-Mn Alloy (1 Mn)	2.73
K	Manganese Bronze (68 Cu, 23 Zn; bal. Fe, Al and Mn)	7.89
L	Brass (85-15)	8.75
M	Brass (70-30)	8.52
N	Admiralty Metal (70 Cu, 29 Zn, 1 Sn)	8.54
O	Duralumin (4 Cu, 0.5 Mn, 0.5 Mg)	2.79
P	Cu-Ni-Zn Alloy (75 Cu, 20 Ni, 5 Zn)	8.84
Q	Cu-Ni-Sn Alloy (70 Cu, 29 Ni, 1 Sn)	8.87
S	Nickel-Copper Alloy (70 Ni, 30 Cu)	8.80
T	Commercial Nickel (99+ per cent Pure)	8.85
U	Chemical Lead (0.06 Cu)	11.35
Z	Al-Mg-Si Alloy (98 Al, 0.5 Mg, 1 Si)	2.69
AA	Commercial Zinc (Prime Western) (0.8 Pb, 0.01 Fe, 0.2 Cd)	7.14
BB	Commercial Zinc (0.05 Pb, 0.02 Fe)	7.14
CC	Lead Antimony Alloy (1 Sb)	11.30
EE	Commercial Tin (99+ per cent Pure)	7.29
FF	Aluminum-Coated Duralumin (Average thickness of coating 0.002 in. on each side)	2.78
HH	Zinc (High Grade, 99.99+ per cent Pure)	7.14

NOTE.—Density data supplied by manufacturers. Compositions are approximate. See 1932 report of Committee B-3 for exact analyses.[1]

In order to find out what part of the total loss in strength or elongation was due to corrosion and what part was due to simple aging effects, it was necessary to pull a set of specimens, which had been stored in a sealed container over soda-lime for a similar length of time. This, of course, makes no allowance for the difference in temperature conditions under which the "storage" specimens were kept as compared to temperature conditions prevailing at the various test locations. At the Bureau of Standards where the storage specimens were kept the temperature varied between 40 F. (4.4 C.) and 90 F. (32 C.). Apparently, in the case of some metals and alloys, these temperature differences were large enough to have influenced the amount of aging which took place in the various sets of exposed specimens as compared to the storage set, with the result that at locations where the corrosion was slight and temperature differences most marked (for example Phoenix, Ariz.) the exposed specimens show higher strengths than the storage set of specimens.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 201 (1932).

Therefore, to eliminate the effect of aging, as far as possible with the data available, the change in tensile strength or percentage elongation was determined by subtracting the results of the corroded specimens from the results of the tests on the storage sets, or *vice versa*, depending on which was the larger, reporting the results in Table IV as the percentage change, referred to the storage set values as a base. The figures appearing in Table IV under the heading Percentage Change are, therefore, the net change in properties due to corrosion plus whatever differences exist between the aging in storage and the aging under exposure conditions. The extent of this latter difference can be approximately evaluated by a careful study of the weight change data and the surface appearance. Where the test results were higher than the values of the storage set, the percentage change figures are prefixed by a positive sign and, where the converse is true, the figures are prefixed by a negative sign. The differences between the values for the storage set and the original test results determined on material just before it was exposed, appear in Table IV as a percentage change referred to the original test data values as a base.

As in the case of the weight changes of the plate specimens, the losses or gains in tensile strength or percentage elongation for some metals and alloys are so small as to be of little consequence, probably falling within the limit of error of the testing machines and testing methods used in most cases. This is not true at all test locations, however, since significant losses in tensile strength and even greater losses in percentage elongation are noted at La Jolla, Calif., in the case of material O, Duralumin; K, Manganese Bronze; AA, Commercial Zinc (Prime Western); and Z, Al-Mg-Si Alloy. Noticeable losses in percentage elongation were also observed at La Jolla in material G, Commercial Aluminum; I, Al-Mn Alloy; and EE, Commercial Tin. A number of the foregoing materials also showed significant losses in percentage elongation at New York City, Pittsburgh, and Altoona.

However, in using changes in tensile properties as a measure of the extent of corrosion, the following comments deserve careful consideration.

Corrosion, which results in a marked surface roughening or pitting or an intercrystalline attack, produces stress concentrations with consequent localization of deformation. This is commonly called the "notch effect." The effect of localized deformation is a marked reduction in the elongation and to a lesser extent a decrease in the tensile strength. This is particularly true in the early stages of exposure where relatively large decreases in elongation result from a comparatively small degree of surface roughening. This oversensitiveness of elongation in the early stages of corrosion should not be overlooked in drawing conclusions or attempting to predict what might result with thick sections from test data secured on thin sheet metals.

With a material of low elongation a small decrease in the actual stretch of the test specimens shows up as a large loss when expressed as percentage change. Furthermore, a direct comparison between two materials is difficult unless the actual elongations are of about the same numerical order. However, a comparison can be made without reservation of elongation figures for the same metal exposed at various test locations. Materials which corrode by a uniform solution of the surface show little change in elongation although their tensile strength is reduced in direct proportion to the reduction in their cross-sectional areas.

In an evaluation procedure the thickness of the sheet is a factor of major importance. The amount of penetration from the surface is largely independent of thickness but the change in properties produced by a given amount of surface roughening will be greater the thinner the sheet. Furthermore, in many metals the rate of corrosion penetration from the surface decreases with increased depth, so that the rate of change in properties, which may be rapid during the earlier period of exposure, shows a considerable decrease as the corrosion period is extended. As a consequence, relatively thick metals will show no significant changes over long periods of exposure to corrosive conditions which produce alarming losses in thin materials in a relatively short time. However, where actual service conditions require the use of thin sheet metals, approximately 0.035 in. in thickness, in atmospheres similar to those included in these tests, the data given in this report can be used as a reliable guide of what may be expected in the changes in tensile properties. Attention is called to the fact that the ratio of edge to surface may have an important bearing on losses in tensile properties. Therefore, the data deserves serious consideration where a knowledge of possible changes in tensile properties is an important factor in selecting a satisfactory metal for a given service condition.

VISUAL INSPECTION OF CORRODED PLATE SPECIMENS

The corroded 9 by 12-in. plates after weighing were inspected by a number of observers to determine, as far as it was possible by such an examination, the amount and character of the corrosion product films. These observations are briefly recorded under the column headed "Remarks" in Table III. In order to condense these remarks certain descriptive terms and phrases were adopted to designate the amount of corrosion products; for example, the term "tarnish" was used to designate a very thin layer of corrosion products; similarly the term "film" was used for corrosion products of moderate thickness and the term "scale" for very thick layers of corrosion products. Also an attempt has been made to describe the color, smoothness, uniformity and adherence of the films.

In general, the corrosion product films are the sort that one should expect would form on the metals and alloys in the various types of atmospheres. For example, in the industrial atmospheres of Pittsburgh, Pa., Altoona, Pa., New York City and Rochester, N. Y. the corrosion products are dark colored on the copper, nickel and copper alloys and light gray on the white metals, all more or less blackened by the soot and dirt deposited on the specimens and incorporated into the fairly thick films. In the two rural locations, State College, Pa., and Phoenix, Ariz., the attack was so slight as to leave the appearance of some of the specimens unchanged while others developed a slight surface tarnish. The three seacoast locations, Sandy Hook, N. J., Key West, Fla., and La Jolla, Calif., showed characteristic differences. At Sandy Hook the films had the appearance usually associated with salt atmospheres, that is, irregular deposits of white and grayish colored salts on the aluminum and aluminum alloys, the tin, the leads and the zincs, greenish colored films on copper and its alloys and light films of greenish color on the nickel and the 70–30 nickel-copper alloys. At Key West the copper and copper alloys showed a characteristic reddish colored film smooth and adherent, while the other materials were about the same as at Sandy Hook. However, at La Jolla the attack was so severe that all the materials, with the exception of lead, nickel, and the 70–30 nickel-copper alloy, showed heavy deposits of corrosion products, greenish or bluish green for the copper and copper alloys, grayish white for the aluminum and aluminum alloys, and heavy white crust-like deposits on the zincs.

TEST ATMOSPHERES

A detailed description of the various test atmospheres appears in the 1932 report of Committee B-3.[1] These are classified as follows:

No. 1.	Brunot Island, Pittsburgh, Pa.	Industrial, inland
No. 2.	Altoona, Pa.	Industrial, inland
No. 3.	State College, Pa.	Rural
No. 4.	New York City	Combination of semi-industrial and partial seacoast exposures
No. 5.	Sandy Hook, N. J.	Northern seacoast
No. 6.	Rochester, N. Y.	High humidity, light industrial
No. 7.	Key West, Fla.	Southern seacoast
No. 8.	Phoenix, Ariz.	Dry inland
No. 9.	La Jolla (San Diego), Calif.	High humidity, seacoast

The summary of the meteorological data in Table III includes data for 1931. A fair idea of the weather conditions at most locations can be had from a study of this information. There are, however, certain factors deserving consideration which are not covered in the usual Weather Bureau reports.

It is apparent from a study of the test data that New York City has as corrosive an atmosphere as any of the other industrial locations. This may be due to the fact that it is surrounded by large bodies of water, the Hudson River, Long Island Sound, Lower New York Bay, which are conducive to high humidity and fogs and also because its industrial atmosphere possibly is made still more corrosive by the presence of chlorides from the ocean, sound and lower bay. It should be kept in mind that the large concentration of population crowded into the relatively small area of the metropolitan district requires the burning of large amounts of fuel for heating and in electric power and gas plants. There is also a large consumption of fuel by the heavy railroad and harbor traffic. All this produces a high concentration of smoke in the air to which must be added the fumes from the industrial districts in Long Island City, Staten Island and the New Jersey meadows. The amount of sulfur dioxide, carbon dioxide, soot and dirt in the atmosphere of New York City is, therefore, probably higher than that of many other cities generally considered more strictly industrial.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 201 (1932).

TABLE III.—SUMMARY OF METEOROLOGICAL DATA FOR 1931[a] AT ATMOSPHERIC TEST LOCATIONS.

Test Location	Elevation Above Sea Level, ft.	Temperature, Deg. Fahr.						Precipitation, in.				Days in 1931, Precipitation (rain and snow) 0.01 in. or over	Snowfall, inches melted	Relative humidity, per cent	Sunshine, per cent of possible	Wind		Type of Exposure
		Mean 1931	Mean Annual	Number of Days in 1931				1931 Total	Yearly Average	Highest Yearly	Lowest Yearly					Average Hourly Velocity, miles per hour	Prevailing Direction	
				Max.	Temp.	Min.	Temp.											
				32 F. and under	90 F. and over	32 F. and under	0 F. and over											
No. 1—Pittsburgh, Pa.	842	55	..	13	21	79	0	39	36	51	23	176	16	73	54	8.7	W.	Industrial
No. 2—Altoona, Pa.	1615			not published														Industrial
No. 3—State College, Pa.	1217	52	48	..	..	..	..	34	39	..	..	113	24	..	..	..	..	Rural
No. 4—New York City	150	55	52	4	11	74	0	35	43	59	33	151	7	66	62	13.4	N.W.	Industrial
No. 5—Sandy Hook, N. J.	22	..	52	..	..	..	..	..	47	51	31	..	..	..	..	..	..	Seacoast
No. 6—Rochester, N. Y.	523	51	48	29	13	101	0	31	33	50	17	154	63	70	50	8.7	W.	Industrial
No. 7—Key West, Fla.	22	76	77	..	..	..	..	51	38	59	22	119	0	77	66	9.1	..	Seacoast
No. 8—Phoenix, Ariz.	1108	72	70	0	174	17	0	10	8	20	3	38	0	38	84	6	E.	Rural
No. 9—La Jolla, Calif.	50	64	..	..	..	..	..	15	10	26	4	48	0	75	67	6.6	W.	Seacoast

[a] Government weather reports not yet published for 1932, hence no information given for portion of exposure period occurring in 1932

At La Jolla, Calif., the light rainfall is offset by the high humidity conditions; also by the numerous heavy fogs and dense mists which drift in from the ocean. These condense on and wet down all exposed surfaces, keeping the corrosion products more or less wet most of the time. This and the very close proximity of the test racks to the beach, where breaking waves throw up a fine mist of salt spray, probably account for the very corrosive atmosphere at this place.

LABORATORY INVESTIGATION OF CORROSION PRODUCT FILMS

Samples were clipped from the ends of the tension specimens before they were tested for use in the laboratory studies of the corrosion product films to be made by the Bureau of Standards. A separate report covering these investigations will be made as soon as the work has advanced far enough.

Acknowledgments.—The chairman wishes to express his thanks for the assistance given him in the preparation of this report by Messrs. E. H. Dix, Jr., W. M. Peirce, F. F. Farnsworth, C. L. Hippensteel, G. O. Hiers, H. E. Searle and J. R. Freeman, Jr. The committee is also most grateful for the assistance of Mr. H. S. Rawdon and his associates in weighing the plate samples and to Messrs. L. K. Doutrick of the Central Arizona Light and Power Co., H. W. Hitchcock of the Southern California Telephone Co., L. M. Pierce of the U. S. Naval Station at Key West, L. Shnidman of the Rochester Gas and Electric Co., C. L. Hippensteel of the Bell Telephone Laboratories, Inc., New York City and M. E. McDonnell of the Pennsylvania Railroad for their careful attention to the removal of specimens from the test racks and their reinstallation after the inspection had been completed.

Respectfully submitted on behalf of the subcommittee,

WILLIAM H. FINKELDEY,
Chairman.

TABLE IV.—REPORT ON INSPECTION OF ATMOSPHERIC CORROSION TESTS OF NON-FERROUS METALS AND ALLOYS EXPOSED AT NINE TEST LOCATIONS.

Commercial Copper (Tough Pitch) Identification Letter, A

Original Test Data: Avg. tensile strength, 35,200 lb. per sq. in.; Avg. elongation in 2 in., 42.4 per cent.

Test Location	After One Year Exposure					
	Physical Properties		Percentage Change		Change in Weight, g.	Remarks
	Average Tensile Strength, lb. per sq. in.	Average Elongation in 2 in., per cent	Tensile Strength	Elongation		
Storage Set	34 180	42.9	−2.9	+0.9	.....	
No. 1. Pittsburgh, Pa.	33 550	42.3	−1.8	−1.4	+1.44 +1.42	Black adherent uniform film
No. 2. Altoona, Pa.	33 750	42.8	−1.3	−0.2	+0.26 +0.29	Brownish black adherent uniform film
No. 3. State College, Pa.	33 880	41.5	−0.9	−3.3	+0.33 +0.33	Reddish brown adherent uniform film
No. 4. New York City	33 820	43.5	−1.0	+1.4	−0.83 −0.83	Reddish brown with green cast adherent uniform film
No. 5. Sandy Hook, N. J.	33 920	43.4	−0.8	+1.1	+0.49 +0.59	Reddish brown with green cast adherent uniform film
No. 6. Rochester, N. Y.	34 100	43.3	−0.2	+0.9	+0.30 +0.28	Reddish brown adherent uniform film
No. 7. Key West, Fla.	34 400	43.8	+0.6	+2.0	+0.42 +0.43	Brownish red adherent uniform film
No. 8. Phoenix, Ariz.	34 270	43.6	+0.3	+1.6	+0.12 +0.14	Mottled orange brown adherent uniform film
No. 9. La Jolla, Calif.	33 980	42.6	−0.6	−0.7	+1.54 +1.48	Red to blue green adherent uniform film

Note.—Tension tests made on 20,000-lb. Amsler machine, range used 0 to 2000 lb., pulling speed 2 in. per minute

Commercial Copper (Phosphorized) Identification Letter, B

Original Test Data: Avg. tensile strength, 35,150 lb. per sq. in.

Test Location	Average Tensile Strength, lb. per sq. in.	Average Elongation in 2 in., per cent	Tensile Strength	Elongation	Change in Weight, g.	Remarks
Storage Set	35 400	43.0	+0.7	.....	.....	
No. 1. Pittsburgh, Pa.	34 500	41.5	−2.5	−3.5	+1.27 +1.15	Black adherent uniform film
No. 2. Altoona, Pa.	34 600	41.5	−2.3	−3.5	+0.06 +0.04	Brownish black adherent uniform film
No. 3. State College, Pa.	34 900	41.0	−1.4	−4.7	+0.32 +0.32	Reddish brown adherent uniform film
No. 4. New York City	34 600	42.0	−2.3	−2.3	−0.84 −0.85	Brown with blue cast adherent uniform film
No. 5. Sandy Hook, N. J.	34 600	42.5	−2.3	−1.2	+0.51 +0.49	Reddish brown with green cast adherent uniform film
No. 6. Rochester, N. Y.	34 900	42.0	−1.4	−2.3	+0.27 +0.27	Reddish brown adherent uniform film
No. 7. Key West, Fla.	35 200	42.0	−0.6	−2.3	+0.38 +0.38	Brownish red adherent uniform film
No. 8. Phoenix, Ariz.	35 200	41.5	−0.6	−3.5	+0.11 +0.13	Mottled orange brown adherent uniform film
No. 9. La Jolla, Calif.	34 700	42.5	−2.0	−1.2	+1.32 +1.40	Red to blue green adherent uniform film

NOTE.—Tension tests made on 20,000-lb. Amsler machine, range used 0 to 2000 lb., pulling speed 0.85 in. per minute.

Copper-Silicon-Manganese Alloy Identification Letter, C

Original Test Data: Avg. tensile strength, 59,050 lb. per sq. in.: Avg. elongation in 2 in., 55.7 per cent.

Test Location	Average Tensile Strength, lb. per sq. in.	Average Elongation in 2 in., per cent	Tensile Strength	Elongation	Change in Weight, g.	Remarks
Storage Set	59 620	55.5	+1.0	−0.3	.....	
No. 1. Pittsburgh, Pa.	57 780	56.2	−3.1	+1.3	+1.42 +1.16	Black adherent uniform film
No. 2. Altoona, Pa.	57 330	56.6	−3.8	+2.0	+0.18 −0.15	Brownish adherent uniform film
No. 3. State College, Pa.	60 070	54.3	+0.8	−2.2	+0.11 −0.05	Yellow brown adherent uniform film
No. 4. New York City	57 530	56.2	−3.5	+1.3	−0.89 −0.88	Slate gray with blue cast adherent uniform film
No. 5. Sandy Hook, N. J.	57 980	56.8	−2.8	+2.3	+0.47 +0.49	Reddish brown with green cast adherent uniform film
No. 6. Rochester, N. Y.	59 570	54.7	−0.08	−1.4	+0.27 +0.26	Yellow brown non-uniform adherent film
No. 7. Key West, Fla.	58 630	56.7	−1.7	+2.2	+0.44 +0.42	Brownish red adherent uniform film
No. 8. Phoenix, Ariz.	59 330	55.6	−0.5	+0.2	+0.12 +0.16	Yellow to black uniform adherent film
No. 9. La Jolla. Calif.	58 540	56.6	−1.8	+2.0	+1.92 +1.77	Red to blue green adherent uniform film

NOTE.—Tension tests made on 20,000-lb. Amsler machine, range used 0 to 2000 lb., pulling speed 2 in. per minute.

TABLE IV.—REPORT ON INSPECTION OF ATMOSPHERIC CORROSION TESTS, ETC. (*Continued*).

Tin Bronze Identification Letter, D

Original Test Data: Avg. tensile strength, 58,925 lb. per sq. in.; Avg. elongation in 2 in., 66.2 per cent.

Test Location	After One Year Exposure					
	Physical Properties		Percentage Change		Change in Weight, g	Remarks
	Average Tensile Strength, lb. per sq. in.	Average Elongation in 2 in., per cent	Tensile Strength	Elongation		
Storage Set	58 300	65.3	−1.1	−1.4	.....	
No. 1. Pittsburgh, Pa	56 900	67.3	−2.4	+3.1	+2.23 +2.26	Black adherent uniform film
No. 2. Altoona, Pa	57 700	66.5	−1.0	+1.8	+0.79 +0.83	Brownish black adherent uniform film
No. 3. State College, Pa	58 800	64.2	+0.9	−1.7	+0.11 +0.14	Yellow to brown with blue cast non-uniform adherent film
No. 4. New York City	57 500	65.5	−1.4	+0.3	−0.22 −0.19	Brown to black non-uniform adherent film
No. 5. Sandy Hook, N. J	57 200	65.3	−1.9	.....	+0.63 +0.65	Reddish brown with green cast adherent uniform film
No. 6. Rochester, N. Y	58 100	65.8	−0.3	+0.8	+0.31 +0.30	Yellow brown uniform adherent film
No. 7. Key West, Fla	58 400	66.0	+0.2	+1.1	+0.52 +0.53	Brownish red adherent uniform film
No. 8. Phoenix, Ariz	58 700	65.2	+0.7	−0.2	+0.14 +0.12	Mottled orange brown adherent uniform film
No. 9. La Jolla, Calif	57 300	66.3	−1.7	+1.5	+1.83 +1.71	Red to blue green uniform non-adherent film

NOTE.—Tension tests made on 30,000-lb. Olsen machine, range used 0 to 5000 lb., pulling speed 0.5 in. per minute.

Aluminum Bronze Identification Letter, F

Original Test Data:
- Locations Nos. 1 to 7: Avg. tensile strength, 74,070 lb. per sq. in.; Avg. elongation in 2 in., 46.6 per cent.
- Locations Nos. 8 and 9: Avg. tensile strength, 82,858 lb. per sq. in.; Avg. elongation in 2 in., 39.9 per cent.

Storage Set	75 825[a] 83 166[b]	45.0[a] 39.5[b]	+2.4 +0.4	−3.4 −1.0	....	
No. 1. Pittsburgh, Pa	73 667	46.9	−2.9	+4.2	+1.57 +1.60	Black adherent uniform film
No. 2. Altoona, Pa	73 775	49.4	−2.7	+9.8	+0.34 +0.47	Brownish black adherent uniform film
No. 3. State College, Pa	76 683	47.2	+1.1	+4.9	−0.03 −0.03	Slight tarnish
No. 4. New York City	72 442	49.9	−3.3	+14.0	−0.03 −0.01	Brown to black uniform adherent film
No. 5. Sandy Hook, N. J	75 042	47.4	−1.0	+5.3	+0.31 +0.31	Reddish brown with green cast adherent uniform film
No. 6. Rochester, N. Y	76 292	46.6	+1.9	+2.2	+0.18 +0.20	Reddish brown adherent uniform film
No. 7. Key West, Fla	75 942	46.3	+0.2	+2.9	+0.26 +0.07	Yellow with red cast uniform adherent film
No. 8. Phoenix, Ariz	82 967	38.5	−0.2	−2.5	+0.09 +0.08	Slight tarnish
No. 9. La Jolla, Calif	83 516	37.2	+0.4	−5.8	+0.93 +0.95	Red to blue green adherent uniform film

NOTE.—Tension tests made on 20,000-lb. Amsler machine, range used 0 to 2000 lb., pulling speed 0.5 in. per minute.

[a] Storage set data for specimens at test locations Nos. 1 to 7.

[b] Storage set data for specimens at test locations Nos. 8 and 9.

Brass (Cu 85, Zn 15) Identification Letter, L

Original Test Data: Avg. tensile strength, 39, 896 lb. per sq. in.; Avg. elongation in 2 in., 40.7 per cent.

Storage Set	40 750	39.7	+2.1	−2.5	.....	
No. 1. Pittsburgh, Pa	39 462	39.2	−3.2	−1.3	+1.36 +1.21	Black adherent uniform film
No. 2. Altoona, Pa	40 054	40.0	−1.7	+0.8	+0.76 +0.72	Black uniform adherent film
No. 3. State College, Pa	40 408	39.9	−0.8	+0.5	+0.01 +0.01	Light brown uniform adherent film
No. 4. New York City	40 558	39.5	−0.5	−0.5	−0.07 −0.12	Black non-uniform adherent film
No. 5. Sandy Hook, N. J	40 034	40.2	−1.8	+1.3	+0.37 +0.37	Reddish brown with green cast adherent uniform film
No. 6. Rochester, N. Y	40 675	39.8	−0.2	+0.3	+0.24 +0.27	Reddish brown adherent uniform film
No. 7. Key West, Fla	40 525	39.5	−0.6	−0.5	+0.24 +0.22	Brownish red adherent uniform film
No. 8. Phoenix, Ariz	40 850	39.9	+0.2	+0.5	+0.10 +0.10	Heavy tarnish
No. 9. La Jolla, Calif	40 092	40.4	−1.6	+1.8	+1.15 +1.08	Red to blue green adherent uniform film

NOTE.—Tension tests made on 20,000-lb. Amsler machine, range used 0 to 4000 lb., pulling speed ⅜ in. per minute.

TABLE IV.—REPORT ON INSPECTION OF ATMOSPHERIC CORROSION TESTS, ETC. (*Continued*).

Brass (Cu 70, Zn 30) Identification Letter, M

Original Test Data: Avg. tensile strength, 48,033 lb. per sq. in.

Test Location	After One Year Exposure					
	Physical Properties		Percentage Change		Change in Weight, g.	Remarks
	Average Tensile Strength, lb. per sq. in.	Average Elongation in 2 in., per cent	Tensile Strength	Elongation		
Storage Set	48 500	57.0	+1.0	.....	.....	
No. 1. Pittsburgh, Pa	46 900	57.0	−3.3	0	−0.45 −0.47	Black adherent uniform film
No. 2. Altoona, Pa	47 400	58.5	−2.3	+2.6	−0.53 −0.50	Brownish black adherent uniform film
No. 3. State College, Pa	48 200	58.5	−0.6	+2.6	−0.05 −0.06	Yellow brown uniform adherent film
No. 4. New York City	45 900	55.0	−5.4	−3.5	−1.42 −1.47	Black uniform adherent film
No. 5. Sandy Hook, N. J	47 400	56.5	−2.3	−0.9	+0.21 +0.23	Reddish brown with green cast adherent uniform film
No. 6. Rochester, N. Y	48 300	60.0	−0.4	+5.3	+0.20 +0.19	Reddish brown adherent uniform film
No. 7. Key West, Fla	48 700	59.5	+0.4	+4.4	−0.14 +0.16	Brown with green on edges adherent film
No. 8. Phoenix, Ariz	49 100	61.0	+1.0	+7.0	+0.12 +0.10	Slight tarnish
No. 9. La Jolla, Calif	46 600	59.5	−3.9	+4.4	+0.82 +0.89	Red with green patches adherent film

NOTE.—Tension tests made on 20,000-lb. Amsler machine, range used 0 to 2000 lb., pulling speed 0.85 in. per minute.

Admiralty Metal Identification Letter, N

Original Test Data: Avg. tensile strength, 54,958 lb. per sq. in.; Avg. elongation in 2 in., 51.1 per cent.

Storage Set	53 900	50.5	−1.9	−1.2	.....	
No. 1. Pittsburgh, Pa	53 200	52.7	−1.3	+4.4	+0.69 +0.74	Black adherent uniform film
No. 2. Altoona, Pa	53 400	51.8	−0.9	+2.6	−0.50 −0.53	Brownish black adherent uniform film
No. 3. State College, Pa	54 200	52.3	+0.6	+3.6	−0.07 −0.07	Yellow brown uniform adherent film
No. 4. New York City	53 600	52.8	−0.6	+4.6	−1.25 −1.26	Brown to gray adherent uniform film
No. 5. Sandy Hook, N. J	54 000	52.2	+0.2	+3.4	+0.26 +0.24	Reddish brown with green cast adherent uniform film
No. 6. Rochester, N. Y	53 900	52.8	0	+4.6	+0.15 +0.19	Reddish brown adherent uniform film
No. 7. Key West, Fla	53 800	51.8	−0.2	+2.6	+0.21 +0.22	Brown with green on edges adherent film
No. 8. Phoenix, Ariz	53 700	51.2	−0.4	+1.4	+0.09 +0.09	Slight tarnish
No. 9. La Jolla, Calif	53 600	53.0	−0.6	+3.0	+0.92 +0.94	Red with green patches uniform adherent film

NOTE.—Tension tests made on 50,000-lb. Olsen machine, range used 0 to 5000 lb., pulling speed 0.5 in. per minute.

Manganese Bronze Identification Letter, K

Original Test Data: Avg. tensile strength, 122,999 lb. per sq. in.: Avg. elongation in 2 in., 8.5 per cent.

Storage Set	121 705	7.4	−1.1	−13.0	.....	
No. 1. Pittsburgh, Pa	118 200	7.1	−2.9	−4.0	+1.24 +1.29	Dark brown adherent film with pinheads of lighter brown corrosion products
No. 2. Altoona, Pa	111 460	8.3	−8.4	+12.0	+1.16 +1.09	Blackish brown adherent film, some occluded soot
No. 3. State College, Pa	124 620	5.8	+2.4	−21.6	−0.05 −0.02	Corrosion slight, practically unchanged
No. 4. New York City	116 980	5.4	−3.9	−27.0	+1.14 +1.12	Dark brown adherent film with pinheads of lighter brown corrosion products
No. 5. Sandy Hook, N. J	133 460	5.5	+9.7	−25.6	+0.85 +0.73	Dark brown adherent film speckled with lighter brown corrosion products
No. 6. Rochester, N. Y	120 680	5.5	−0.8	−25.6	+0.46 +0.43	Dark brown adherent film with pinheads of lighter brown corrosion products
No. 7. Key West, Fla	124 970	6.1	+2.7	−17.6	+0.56 +0.56	Dark brown adherent film
No. 8. Phoenix, Ariz	124 755	6.1	+2.5	−17.6	+0.09 +0.10	Corrosion slight, practically unchanged
No. 9. La Jolla Calif	98 550	2.5	−19.0	−66.2	+1.50 +1.65	Dark brown film with small tubercles of light colored corrosion products

NOTE.—Tension tests made on 100,000-lb. Olsen machine, range used not given, pulling speed 0.2 in. per minute.

TABLE IV.—REPORT ON INSPECTION OF ATMOSPHERIC CORROSION TESTS, ETC. (*Continued*).

Copper-Nickel-Zinc Alloy Identification Letter, P

Original Test Data: Avg. tensile strength, 54,350 lb. per sq. in.; Avg. elongation in 2 in., 31.5 per cent.

Test Location	After One Year Exposure					
	Physical Properties		Percentage Change		Change in Weight, g.	Remarks
	Average Tensile Strength, lb. per sq. in.	Average Elongation in 2 in., per cent	Tensile Strength	Elongation		
Storage Set	54 000	31.8	−0.6	+0.9	.....	
No. 1. Pittsburgh, Pa	52 150	31.9	−3.4	+0.3	+0.25 +0.23	Black adherent uniform film
No. 2. Altoona, Pa	53 220	31.8	−1.4	0	−0.43 −0.43	Brown to black adherent uniform film
No. 3. State College, Pa	53 480	32.1	−1.0	+0.9	−0.06 −0.07	Olive green adherent uniform tarnish film
No. 4. New York City	52 620	31.7	−2.6	−0.3	−1.29 −1.34	Mottled brown and gray uniform adherent film
No. 5. Sandy Hook, N. J	53 070	32.1	−1.7	+0.9	+0.09 +0.10	Reddish brown with green cast uniform adherent film
No. 6. Rochester, N. Y	53 720	31.9	−0.5	+0.3	+0.20 +0.19	Brown uniform adherent film
No. 7. Key West, Fla	52 880	31.9	−2.1	+0.3	+0.08 +0.08	Tarnished
No. 8. Phoenix, Ariz	53 630	32.0	−0.7	+0.6	+0.09 +0.11	Slight tarnish
No. 9. La Jolla, Calif	53 500	31.7	−0.9	−0.3	+0.50 +0.46	Light green uniform adherent film

NOTE.—Tension tests made on 20,000-lb. Amsler machine, range used 0 to 2000 lb., pulling speed 2 in. per minute.

Copper-Nickel-Tin Alloy Identification Letter, Q

Original Test Data: Avg. tensile strength, 76,792 lb. per sq. in.; Avg. elongation in 2 in., 24.2 per cent.

Storage Set	75 800	25.2	−1.3	+4.0	.....	
No. 1. Pittsburgh, Pa	77 300	23.3	+2.0	−7.5	0 −0.05	Black adherent uniform film
No. 2. Altoona, Pa	80 900	20.8	+6.7	−17.4	−0.74 −0.69	Brown to black adherent uniform film
No. 3. State College, Pa	78 100	23.2	+3.0	−7.9	−0.11 −0.11	Slight tarnish
No. 4. New York City	77 600	23.8	+2.4	−5.5	−1.34 −1.35	Mottled brown and gray uniform adherent film
No. 5. Sandy Hook, N. J	78 800	22.7	+4.0	−9.9	+0.10 +0.10	Olive green uniform adherent film
No. 6. Rochester, N. Y	78 200	22.8	+3.2	−9.5	+0.13 +0.17	Mottled brown to olive green uniform adherent film
No. 7. Key West, Fla	74 900	27.0	−1.2	+7.2	+0.05 +0.07	Tarnished
No. 8. Phoenix, Ariz	76 500	24.7	−0.9	−2.0	+0.08 +0.08	Slight tarnish
No. 9. La Jolla Calif	77 600	23.0	+2.4	−8.7	+0.31 +0.33	Light green uniform adherent film

NOTE.—Tension tests made on 50,000-lb. Olsen machine, range used 0 to 5000 lb., pulling speed 0.5 in. per minute.

Nickel-Copper Alloy Identification Letter, S

Original Test Data: Avg. tensile strength, 79,835 lb. per sq. in.; Avg. elongation in 2 in., 35.7 per cent.

Storage Set	77 900	35.6	−2.4	−0.3	.....	
No. 1. Pittsburgh, Pa	78 950	35.7	+1.4	+0.3	−1.14 −1.12	Black uniform adherent film
No. 2. Altoona, Pa	78 400	35.2	+0.6	−1.1	−1.10 −1.09	Black uniform adherent film with greenish colored spots
No. 3. State College, Pa	77 700	36.0	−0.3	+1.1	−0.15 −0.16	Unchanged
No. 4. New York City	77 100	36.3	−1.0	+2.0	−1.61 −1.65	Black uniform adherent film
No. 5. Sandy Hook, N. J	79 100	35.6	+1.5	0	−0.44 −0.41	Light green uniform adherent film
No. 6. Rochester, N. Y	78 500	35.5	+0.8	−0.3	−0.16 +0.17	Tarnished, spotted with brown stain
No. 7. Key West, Fla	78 500	35.4	+0.8	−0.6	−0.10 −0.08	Light green uniform adherent film
No. 8. Phoenix, Ariz	79 400	35.6	+1.9	0	+0.02 +0.02	Unchanged
No. 9. La Jolla, Calif	78 700	35.2	+1.0	−1.1	+0.15 +0.19	Irregular patches light greenish film

NOTE.—Tension tests made on 20,000-lb. Olsen machine, range used 0 to 20,000 lb., pulling speed 0.5 in. per minute.

TABLE IV.—REPORT ON INSPECTION OF ATMOSPHERIC CORROSION TESTS, ETC. (*Continued*).

Commercial Nickel Identification Letter, T

Original Test Data: Avg. tensile strength, 71,040 lb. per sq. in.; Avg. elongation in 2 in., 35.8 per cent.

Test Location	After One Year Exposure					
	Physical Properties		Percentage Change		Change in Weight, g.	Remarks
	Average Tensile Strength, lb. per sq. in.	Average Elongation in 2 in., per cent	Tensile Strength	Elongation		
Storage Set	72 050	36.8	+1.4	+2.8	.....	
No. 1. Pittsburgh, Pa	71 000	36.4	−1.5	−1.1	−3.90 −3.86	Blackish green uniform adherent film
No. 2. Altoona, Pa	70 850	37.1	−1.7	+0.8	−3.83 −3.95	Greenish black uniform adherent film overlain with pale green streaks and patches of corrosion products
No. 3. State College, Pa	71 470	36.8	−0.8	0	−0.12 −0.12	Unchanged
No. 4. New York City	70 555	36.4	−2.1	−1.1	−5.01 −5.07	Blackish green uniform adherent film
No. 5. Sandy Hook, N. J	71 000	35.9	−0.2	−2.4	−0.74 −0.74	Light greenish brown uniform adherent film
No. 6. Rochester, N. Y	71 900	36.3	−0.2	−1.4	−0.53 −0.54	Tarnished, spotted with brown stains
No. 7. Key West, Fla	71 300	36.5	−1.2	−0.8	−0.14 −0.14	Slightly tarnished
No. 8. Phoenix, Ariz	71 400	35.6	−0.9	−3.3	0 0	Unchanged
No. 9. La Jolla, Calif	71 800	36.5	−0.31	−0.8	+0.08 +0.10	Irregular patches light greenish corrosion products

NOTE.—Tension tests made on 20,000-lb. Olsen machine, range used 0 to 20,000 lb., pulling speed 0.5 in. per minute.

Commercial Aluminum Identification Letter, G

Original Test Data: Avg. tensile strength, 16,410 lb. per sq. in.; Avg. elongation in 2 in., 14.6 per cent.

Storage Set	16 215	14.2	−1.2	−2.7	.....	
No. 1. Pittsburgh, Pa	16 300	12.3	+0.5	−13.4	+0.25 +0.23	Gray uniform adherent film some evidence of soot occluded in film
No. 2. Altoona, Pa	16 460	12.4	+1.5	−12.7	+0.31 +0.27	Dark gray uniform adherent film, with much occluded soot
No. 3. State College, Pa	16 765	13.5	+3.4	−4.9	0 +0.01	Practically unchanged, slightly tarnished
No. 4. New York City	16 525	11.4	+1.9	−19.7	+0.39 +0.36	Dark gray uniform adherent film, some occluded soot
No. 5. Sandy Hook, N. J	16 840	11.9	+3.9	−16.2	+0.28 +0.26	Light gray speckled adherent film non-uniform corrosion
No. 6. Rochester, N. Y	16 605	13.1	+2.4	−7.7	+0.09 +0.10	Light gray uniform adherent film
No. 7. Key West, Fla	16 665	12.8	+2.8	−9.9	+0.09 +0.14	Light gray speckled film, non-uniform attack
No. 8. Phoenix, Ariz	16 775	12.6	+3.5	−11.2	+0.04 +0.04	Unchanged
No. 9. La Jolla, Calif	15 850	4.4	−2.2	−69.0	+0.76 +0.76	Light gray speckled film, non-uniform attack

NOTE.—Tension tests made on 20,000-lb. Amsler machine, range used 0 to 400 lb., pulling speed 0.2 in. per minute.

Aluminum-Manganese Alloy Identification Letter, I

Original Test Data: Avg. tensile strength, 20,450 lb. per sq. in.; Avg. elongation in 2 in., 9.4 per cent.

Storage Set	20 505	10.0	+0.3	+6.4	.....	
No. 1. Pittsburgh, Pa	19 905	8.3	−3.0	−17.0	+0.21 +0.21	Gray uniform adherent film some evidence of soot occluded in film
No. 2. Altoona, Pa	19 805	8.3	−3.4	−17.0	+0.25 +0.23	Dark gray uniform adherent film, with much occluded soot
No. 3. State College, Pa	20 395	9.3	−0.5	−7.0	+0.10 0	Practically unchanged, slightly tarnished
No. 4. New York City	20 060	6.9	−2.2	−31.0	+0.22 +0.24	Dark gray uniform adherent film, some occluded soot
No. 5. Sandy Hook, N. J	20 100	9.1	−2.0	−9.0	+0.16 +0.24	Light gray speckled adherent film non-uniform corrosion
No. 6. Rochester, N. Y	20 345	9.3	−0.8	−7.0	+0.13 +0.14	Light gray uniform adherent film
No. 7. Key West, Fla	20 355	9.6	−0.7	−4.0	+0.08 +0.09	Light gray speckled film, non-uniform attack
No. 8. Phoenix, Ariz	20 475	10.2	−0.1	+2.0	+0.03 +0.03	Unchanged
No. 9. La Jolla, Calif	20 200	5.8	−1.5	−42.0	+0.58 +0.56	Light gray speckled film, non-uniform attack

NOTE.—Tension tests made on 20,000-lb. Amsler machine, range used 0 to 400 lb., pulling speed 0.2 in. per minute.

TABLE IV.—REPORT ON INSPECTION OF ATMOSPHERIC CORROSION TESTS, ETC. (*Continued*).

Aluminum-Magnesium-Silicon Alloy Identification Letter, Z

Original Test Data: Avg. tensile strength, 37,975 lb. per sq. in.; Avg. elongation in 2 in., 23.9 per cent.

Test Location	After One Year Exposure					
	Physical Properties		Percentage Change		Change in Weight, g.	Remarks
	Average Tensile Strength, lb. per sq. in.	Average Elongation in 2 in., per cent	Tensile Strength	Elongation		
Storage Set	40 455	24.9	+6.5	+4.2	.....	
No. 1. Pittsburgh, Pa.	39 405	19.5	−2.6	−21.6	+0.22 +0.21	Gray uniform adherent film, some evidence of soot occluded in film
No. 2. Altoona, Pa.	38 180	19.3	−5.6	−22.5	+0.25 +0.22	Dark gray uniform adherent film, with much occluded soot
No. 3. State College, Pa.	40 215	22.6	−0.6	−9.2	−0.01 −0.01	Practically unchanged, slightly tarnished
No. 4. New York City	38 225	15.2	−5.5	−38.9	+0.32 +0.33	Dark gray uniform adherent film, some occluded soot
No. 5. Sandy Hook, N. J.	39 140	18.0	−3.3	−27.7	+0.22 +0.21	Light gray speckled adherent film, non-uniform corrosion
No. 6. Rochester, N. Y.	40 095	21.9	−0.9	−12.0	+0.11 +0.09	Light gray uniform adherent film
No. 7. Key West, Fla.	40 020	17.5	−1.1	−29.7	+0.13 +0.09	Light gray speckled film, attack non-uniform
No. 8. Phoenix, Ariz.	41 200	21.1	+1.8	−15.2	+0.02 +0.03	Tarnished, some speckled areas of light gray adherent film
No. 9. La Jolla, Calif.	32 205	5.8	−20.4	−76.7	+0.78 +0.85	Light gray speckled film, non-uniform attack

NOTE.—Tension tests made on 20,000-lb. Amsler machine, range used 0 to 1000 lb., pulling speed 0.2 in. per minute.

Duralumin Identification Letter, O

Original Test Data: Avg. tensile strength, 63,760 lb. per sq. in.; Avg. elongation in 2 in., 20.7 per cent.

Storage Set	65 430	20.7	+2.6	0	.....	
No. 1. Pittsburgh, Pa.	62 890	16.0	−3.9	−22.6	+0.73 +0.84	Gray uniform adherent film, some evidence of soot occluded in film
No. 2. Altoona, Pa.	58 860	11.3	−10.0	−45.4	+0.68 +0.66	Dark gray uniform adherent film, with much occluded soot
No. 3. State College, Pa.	65 905	19.2	+0.7	−7.2	−0.01 −0.01	Practically unchanged, slightly tarnished
No. 4. New York City	59 835	11.1	−8.5	−46.3	+0.87 +1.04	Dark gray uniform adherent film, some occluded soot
No. 5. Sandy Hook, N. J.	59 220	11.5	−9.5	−44.5	+1.05 +1.09	Light gray uniform adherent film
No. 6. Rochester, N. Y.	63 555	15.9	−2.9	−23.2	+0.42 +0.49	Light gray uniform adherent film
No. 7. Key West, Fla.	62 760	13.0	−4.1	−37.2	+0.87 +0.64	Light gray speckled film, attack non-uniform
No. 8. Phoenix, Ariz.	64 960	19.5	−0.7	−5.8	+0.06 +0.10	Light gray adherent non-uniform film
No. 9. La Jolla, Calif.	42 950	1.7	−34.5	−91.7	+2.89 +2.84	Light gray film speckled with incrustations of white colored corrosion products

NOTE.—Tension tests made on 20,000-lb. Amsler machine, range used 0 to 2000 lb., pulling speed 0.2 in. per minute.

Aluminum-Coated Duralumin Identification Letter, FF

Original Test Data: Avg. tensile strength, 58,790 lb. per sq. in.: Avg. elongation in 2 in., 19.5 per cent.

Storage Set	59 535	19.6	+1.3	+0.5	.....	
No. 1. Pittsburgh, Pa.	58 910	18.4	−1.1	−6.1	+0.20 +0.18	Gray uniform adherent film, some evidence of soot occluded in film
No. 2. Altoona, Pa.	59 140	19.3	−0.7	−1.5	+0.27 +0.24	Dark gray uniform adherent film, with much occluded soot
No. 3. State College, Pa.	58 640	18.0	−1.5	−8.2	−0.01 +0.09	Practically unchanged, slightly tarnished
No. 4. New York City	59 275	19.3	−0.4	−1.5	+0.35 +0.32	Dark gray uniform adherent film, some occluded soot
No. 5. Sandy Hook, N. J.	59 340	18.8	−0.3	−4.1	+0.20 +0.23	Light gray speckled adherent film, non-uniform corrosion
No. 6. Rochester, N. Y.	59 030	18.5	−0.9	−5.6	+0.12 +0.11	Light gray uniform adherent film
No. 7. Key West, Fla.	60 240	18.6	+1.2	−5.1	+0.09 +0.07	Light gray speckled film, non-uniform attack
No. 8. Phoenix, Ariz.	59 570	18.2	+0.1	−7.1	+0.03 +0.03	Practically unchanged
No. 9. La Jolla, Calif.	59 540	18.8	0	−4.1	+0.62 +0.63	Light gray speckled film, non-uniform attack

NOTE.—Tension tests made on 20,000-lb. Amsler machine, range used 0 to 2000 lb., pulling speed 0.2 in. per minute.

TABLE IV.—REPORT ON INSPECTION OF ATMOSPHERIC CORROSION TESTS, ETC. (*Continued*).

Commercial Zinc (High Grade 99.99 + per cent) Identification Letter, HH

Original Test Data: Avg. tensile strength, 18,800 lb. per sq. in.; Avg. elongation in 2 in., 51.6 per cent.

Test Location	After One Year Exposure					
	Physical Properties		Percentage Change		Change in Weight, g.	Remarks
	Average Tensile Strength, lb. per sq. in.	Average Elongation in 2 in., per cent	Tensile Strength	Elongation		
Storage Set	18 600	55.9	−1.1	+8.3	.....	
No. 1. Pittsburgh, Pa	18 100	55.5	−2.7	−0.7	−2.52 −2.29	Light gray thin uniform adherent film
No. 2. Altoona, Pa	17 500	52.4	−5.9	−6.3	−2.92 −2.83	Light gray thin uniform adherent film
No. 3. State College, Pa	18 250	52.6	−1.9	−5.9	−0.13 −0.07	Light gray uniform adherent film
No. 4. New York City	18 000	53.8	−3.2	−3.7	−3.68 −3.66	Light gray thin uniform adherent film
No. 5. Sandy Hook, N. J	18 350	56.2	−1.3	+0.5	−0.44 −0.46	Light gray uniform adherent film
No. 6. Rochester, N. Y	18 450	52.9	−0.8	−5.3	−0.22 −0.22	Light gray thin uniform adherent film
No. 7. Key West, Fla	18 600	51.8	0	−7.3	+0.14 +0.22	Light gray uniform adherent film
No. 8. Phoenix, Ariz	18 700	54.3	+0.5	−2.9	+0.09 +0.09	Distinctly tarnished with areas of light gray adherent film
No. 9. La Jolla, Calif	17 850	47.8	−4.0	−14.5	+2.53 +2.40	Heavy white bulky scale of irregular thickness

NOTE.—Tension tests made on 10,000-lb. Amsler machine, range used 0 to 1000 lb., pulling speed approximately 0.2 in. per minute.

Commercial Zinc (High Grade) Identification Letter, BB

Original Test Data: Avg. tensile strength, 18,280 lb. per sq. in.; Avg. elongation in 2 in., 58.5 per cent.

Storage Set	18 600	56.3	+1.8	−3.8	.....	
No. 1. Pittsburgh, Pa	18 100	55.3	−2.7	−1.8	−2.35 −2.34	Light gray thin uniform adherent film
No. 2. Altoona, Pa	18 200	52.5	−2.1	−6.7	−2.84 −2.80	Light gray thin uniform adherent film
No. 3. State College, Pa	18 360[a]	....	−1.3	.....	−0.27 −0.27	Light gray uniform adherent film
No. 4. New York City	18 200	55.5	−2.1	−1.4	−3.65 −3.60	Light gray thin uniform adherent film
No. 5. Sandy Hook, N. J	18 400	57.9	−1.1	+2.8	−0.49 −0.59	Light gray uniform adherent film
No. 6. Rochester, N. Y	18 500	55.8	−0.5	−0.9	−0.26 −0.26	Light gray thin uniform adherent film
No. 7. Key West, Fla	18 700	56.8	+0.5	+0.9	+0.13 +0.13	Light gray uniform adherent film
No. 8. Phoenix, Ariz	18 700	55.9	+0.5	−0.7	+0.08 +0.08	Distinctly tarnished with areas of light gray adherent film
No. 9. La Jolla, Calif	17 800	50.2	−4.3	−10.8	+2.98 +3.10	Heavy white bulky scale of irregular thickness

NOTE.—Tension tests made on 20,000-lb. Emery machine, range used 0 to 1000 lb., pulling speed 0.25 in. per minute.

[a] Broke outside of gage length.

Commercial Zinc (Prime Western) Identification Letter, AA

Original Test Data: Avg. tensile strength, 29,900 lb. per sq. in.; Avg. elongation in 2 in., 34.3 per cent.

Storage Set	29 600	38.8	−1.0	+13.1	.....	
No. 1. Pittsburgh, Pa	27 900	34.6	−5.7	−10.8	−2.21 −2.30	Light gray thin uniform adherent film
No. 2. Altoona, Pa	28 700	34.0	−3.0	−12.4	−2.67 −2.73	Light gray thin uniform adherent film
No. 3. State College, Pa	29 000	34.8	−2.0	−10.3	−0.06 −0.11	Light gray uniform adherent film
No. 4. New York City	28 500	31.7	−3.7	−18.3	−3.27 −3.23	Light gray thin uniform adherent film
No. 5. Sandy Hook, N. J	29 100	33.5	−1.7	−13.6	−0.45 −0.45	Light gray uniform adherent film
No. 6. Rochester, N. Y	29 600	32.4	0	−16.5	−0.20 −0.24	Light gray thin uniform adherent film
No. 7. Key West, Fla	29 700	36.0	+0.3	−7.2	+0.20 +0.31	Light gray uniform adherent film
No. 8. Phoenix, Ariz	30 000	34.2	+1.4	−11.8	+0.11 +0.12	Distinctly tarnished with areas of light gray adherent film
No. 9. La Jolla, Calif	26 600	11.9	−10.0	−69.3	+2.68 +3.10	Heavy white bulky scale of irregular thickness

NOTE.—Tension tests made on 20,000-lb. Emery machine, range used 0 to 1000 lb., pulling speed 0.25 in. per minute.

TABLE IV.—REPORT ON INSPECTION OF ATMOSPHERIC CORROSION TESTS, ETC. (*Continued*).

Chemical Lead Identification Letter, U

Original Test Data: Avg. tensile strength, 2582 lb. per sq. in.; Avg. elongation in 2 in., 43.6 per cent.

Test Location	After One Year Exposure					
	Physical Properties		Percentage Change		Change in Weight, g.	Remarks
	Average Tensile Strength, lb. per sq. in.	Average Elongation in 2 in., per cent	Tensile Strength	Elongation		
Storage Set	2338	42.7	−9.5	−2.1	.....	
No. 1. Pittsburgh, Pa	2392	38.9	+2.3	−8.9	+0.14 +0.03	Dark gray adherent uniform film
No. 2. Altoona, Pa	2421	39.3	+3.5	−8.0	−0.21 −0.24	Dark gray adherent uniform film
No. 3. State College, Pa	2429	40.2	+3.9	−5.9	+0.02 −0.10	Dark gray adherent film speckled with white corrosion products
No. 4. New York City	2391	41.6	+2.3	−2.6	−0.04 −0.11	Light gray adherent uniform film
No. 5. Sandy Hook, N. J	2387	42.3	+2.1	−0.9	−0.13 −0.17	Light gray adherent uniform film
No. 6. Rochester, N. Y	2488	41.5	+6.4	−2.8	+0.04 0	Dark gray adherent film speckled and streaked white corrosion products
No. 7. Key West, Fla	2453	38.9	+4.9	−8.9	−0.50 −0.45	Dark gray adherent film with streaks of lighter gray corrosion products
No. 8. Phoenix, Ariz	2502	43.7	+7.0	+2.3	−0.04 −0.03	Dark gray uniform adherent film
No. 9. La Jolla, Calif	2361	38.8	+1.0	−9.2	+0.29 +0.33	Light gray uniform adherent film

NOTE.—Tension tests made on 20,000-lb. Amsler machine, range used 0 to 1000 lb., pulling speed 0.5 in. per minute.

Lead-Antimony Alloy (1 per cent Antimony) Identification Letter, CC

Original Test Data: Avg. tensile strength, 3482 lb. per sq. in.; Avg. elongation in 2 in., 45.3 per cent.

Storage Set	3214	46.3	−7.7	+2.2	.....	
No. 1. Pittsburgh, Pa	3351	42.3	+4.3	−8.6	0 +0.04	Dark gray adherent uniform film
No. 2. Altoona, Pa	3273	43.8	+1.8	−5.4	−0.15 −0.16	Dark gray adherent uniform film
No. 3. State College, Pa	3309	45.1	+3.0	−2.6	−0.21 −0.20	Dark gray adherent uniform film
No. 4. New York City	3235	43.8	+0.7	−5.4	−0.02 0	Dark gray adherent uniform film
No. 5. Sandy Hook, N. J	3230	43.1	+0.5	−6.9	−0.04 −0.16	Dark gray adherent uniform film
No. 6. Rochester, N. Y	3265	46.1	+1.6	−0.4	+0.03 +0.02	Heavily tarnished with areas of dark gray adherent film
No. 7. Key West, Fla	3304	43.4	+2.8	−6.2	−0.33 −0.34	Heavily tarnished with areas of dark gray adherent film
No. 8. Phoenix, Ariz	3274	44.3	+1.9	−4.3	−0.05 −0.03	Heavily tarnished with areas of dark gray adherent film
No. 9. La Jolla, Calif	3219	41.8	+0.2	−9.7	+1.37 +0.77	Light gray uniform adherent film

NOTE.—Tension tests made on 20,000-lb. Amsler machine, range used 0 to 1000 lb., pulling speed 0.5 in. per minute.

Commercial Tin Identification Letter, EE

Original Test Data: Avg. tensile strength, 3760 lb. per sq. in.; Avg. elongation in 2 in., 60.3 per cent.

Storage Set	3390	58.7	−9.8	−2.6	.....	
No. 1. Pittsburgh, Pa	3340	60.2	−1.5	+2.6	+0.33 +0.32	Light gray adherent film speckled with white corrosion products, some occluded soot
No. 2. Altoona, Pa	3530	59.1	+4.1	+0.7	+0.45 +0.46	Dark gray adherent film speckled with lighter gray corrosion products, much occluded soot
No. 3. State College, Pa	3530	60.0	+4.1	+2.2	+0.19 +0.17	Light gray adherent film
No. 4. New York City	3420	54.7	+0.9	−6.8	+0.50 +0.52	Dark gray uniform adherent film
No. 5. Sandy Hook, N. J	3440	46.2	+1.5	−21.3	+1.04 +1.00	Light gray adherent film speckled with grayish white corrosion products
No. 6. Rochester, N. Y	3450	58.3	+1.8	−0.7	+0.33 +0.33	Heavily tarnished, speckled with light gray corrosion product film
No. 7. Key West, Fla	3530	55.0	+4.1	−6.3	+0.43 +0.47	Light gray adherent film speckled with grayish white corrosion products
No. 8. Phoenix, Ariz	3360	54.3	−0.9	−7.5	+0.14 +0.14	Heavily tarnished, speckled with light gray corrosion product film
No. 9. La Jolla, Calif	3270	27.0	−3.5	−54.0	+1.50 +1.45	Light gray film, irregular areas incrusted with white bulky scale, yellowish centered

NOTE.—Tension tests made on 20,000-lb. Amsler machine, range used 0 to 1000 lb., pulling speed 0.5 in. per minute.

REPORT OF COMMITTEE B-4

ON

ELECTRICAL-HEATING, ELECTRICAL-RESISTANCE AND ELECTRIC-FURNACE ALLOYS

One meeting of Committee B-4 was held in New York City on February 24, 1933, in addition to the meeting held during the 1932 annual meeting of the Society.

The present membership of the committee is 26, of which 12 are classified as producers, 11 as consumers and 3 as general interests.

Recommendations Affecting Standards

Advancement of Tentative Standards to Standard.—The committee recommends that the following two tentative standards be advanced to standard, with revisions as indicated below:

Tentative Accelerated Life Test for Metallic Materials for Electrical Heating (B 76 - 29 T):[1]

Section 2 (a).—Change the note following this section to read as follows by the addition of the italicized words:

> Note.—*The cover or shield over the wire must be a tight fit on the board and the slide and pyrometer tube should fit snugly to prevent leakage of air at this point while observations are being taken, as* even a slight draught of air in contact with the specimen will cause excessive variation in the length of life.

Section 3.—Change Paragraph (*e*) to read as follows by the addition of the italicized words and figures and the omission of the words in brackets:

> (*e*) Ammeter and Voltmeter.—The ammeter and voltmeter shall have an accuracy of 1 per cent of [full scale] ***normal test*** deflection [and] (***approximately 15 amp. and 15 v., respectively***). For alternating current the range used shall be such as to give a reading above the lower fifth of the scale range. ***The ammeter has appreciable resistance; therefore, after it has been cut out of circuit, a slight readjustment of current with the slider will be necessary to bring the voltmeter back to the value corresponding to standard test temperature.***

Change the last sentence of Paragraph (*h*) to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

> If no recording pyrometer is available some form of bell ringing device [may be used as shown in Fig. 1] ***or electric clock mechanism which can be con-***

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[1] ***Proceedings***, **Am. Soc. Testing Mats., Vol. 29, Part I, p. 613 (1929); also 1932 Book of A.S.T.M. Tentative Standards, p. 280.**

nected into the circuit may be used as shown in B-B, Fig. 1. This circuit is closed when the specimen under test burns out and allows the weight to drop onto the phosphor bronze spring, causing it to make electrical connection through the contacts.

Section 5.—Change the first sentence of Paragraph (*b*) to read as follows by the omission of the figure and letter in brackets:

> In mounting a test specimen, one end of the specimen shall be inserted in the upper terminal and the [10-g.] weight attached to the other end.

Section 8.—Change Paragraph (*e*) to read as follows by the omission of the figure and letter in brackets:

> (*e*) Grasp the [10-g.] weight in a pair of pliers and apply a slight tension, sufficient to straighten the wire.

Change the third sentence of Paragraph (*h*) to read as follows by the addition of the italicized word and the omission of the word in brackets:

> Final adjustment shall be completed within [ten] *fifteen* minutes from the time of starting the test.

Change Paragraph (*i*) to read as follows by the addition of the italicized word and the omission of the word in brackets:

> (*i*) Record the voltage and the current, together with the starting temperature and the starting time at the end of the [ten] *fifteen*-minute period.

Change the first sentence of Paragraph (*k*) to read as follows by the addition of the italicized figure and the omission of the word and figures in brackets:

> Adjust the temperature to the standard test temperature after [3] *5* hours, [7 hours] and 24 hours total elapsed time.

Section 10.—Change Paragraphs (*d*) and (*e*) to read as follows by the addition of the italicized word and the omission of the word in brackets:

> (*d*) Life of the specimen in hours (total elapsed time from the end of the first [ten] *fifteen*-minute aging period to burnout);
>
> (*e*) The elapsed time in hours to 10 per cent increase in resistance, starting after the end of the first [ten] *fifteen*-minute aging period.

Table I.—In the second and third columns of the lower half of the table change "10 minutes" to read "15 minutes."

Appendix.—Add as an Appendix to this method the comments appended hereto.[1]

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[1] The Appendix has been incorporated in the Standard Accelerated Life Test for Metallic Materials for Electrical Heating, see 1933 Book of A.S.T.M. Standards, Part I, p. 877.—ED.

Tentative Method of Test for Thermoelectric Power (B 77 - 30 T):[1]

Title.—Change the title of this method by the addition of the words "of Electrical-Resistance Alloys."

Section 3.—Change the definition of the term "thermoelectric power" from its present form: namely,

> 3. *Thermoelectric Power.*—The thermoelectric power, *Q*, of one metal with respect to another is defined as the electromotive force in an electric circuit which consists of these two metals when the junctions between the two metals have a 1 C. difference in temperature.

to read as follows:

> 3. *Thermoelectric Power.*—The thermoelectric power, *Q*, of two metals is the electromotive force in an electric circuit consisting of the two metals when the junctions between them have a difference in temperature of 1 C.

Section 5.—Change to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

> 5. As a matter of precaution, the [temperatures] ***average temperature*** used in determining the thermoelectric power should be approximately the same as that to which the material will be subjected in practice ***and in no case should*** *the temperature difference between the two junctions be less than 20 C.* The temperature at each of the two junctions shall be measured by a device which is sufficiently accurate to determine the temperature difference with an error not exceeding 5 per cent. A convenient method [of] *for* determining the temperature of the junctions is to immerse each junction in a [beaker] ***bath*** of oil which is maintained at the desired temperature. ***Baths which are stirred and the temperatures of which are thermostatically controlled are to be preferred.*** [The] ***However***, beakers [shall be] ***of oil which are*** supported by blocks of metal, sand baths or other means [whose] ***may be used provided the*** thermal capacity ***of such assemblies*** [is] ***are*** such that when the [supply of] heat is cut off their temperatures will decrease at rates less than 0.2 C. per minute. The temperature of the oil in each [beaker] ***bath*** may be determined ***either*** by a ***calibrated*** mercury thermometer graduated in Centigrade degrees [the range being 0 to 100 C.], ***or by a calibrated thermocouple. If the oil is not stirred, the junctions shall be placed in close proximity to the temperature-measuring instrument.*** To insure that the temperatures of the junctions shall not be influenced by heat ***of*** conduction along the specimen, the [distance in each beaker from] ***length of each specimen from the junction to the point where it leaves*** the surface of the oil [to the junction] shall not be less than ten times the minimum cross-section dimension of the resistance material nor less than one hundred times the minimum cross-section [dimension] of the copper leads and in no case less than 2 in.

Section 8.—Add a new item (*c*) to read as follows, relettering the present item (*c*) and subsequent items accordingly:

> (*c*) Method of determining temperature of junctions.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30. Part I, p. 1013 (1930); also 1932 Book of A.S.T.M. Tentative Standards, p. 289.

The recommendations in this report have been submitted to letter ballot of the committee, which consists of 26 members, with the following results:

Items	Affirmative	Negative	Not Voting
I. ADVANCEMENT OF TENTATIVE STANDARDS TO STANDARD			
Accelerated Life Test for Metallic Materials for Electrical Heating (B 76 - 29 T), as revised	17	0	6
Test for Thermoelectric Power (B 77 - 30 T), as revised	19	0	4

ACTIVITIES OF SUBCOMMITTEES

Subcommittee I on Life Tests (J. W. Harsch, chairman).—The Tentative Accelerated Life Test for Metallic Materials for Electrical Heating (B 76 - 29 T) has been reviewed and the modifications mentioned earlier in this report as well as certain editorial changes have been proposed as found necessary by experience in service. The method as revised is recommended for adoption as standard. Reference has been made to the paper by F. E. Bash and J. W. Harsch presented before the Society in 1929,[1] which explains important considerations in connection with this method of test.

Subcommittee II on Electrical Tests (H. L. Curtis, chairman).—A further study is being made of the Tentative Method of Test for Determining the Temperature-Resistance Constants of Resistance Alloys (B 84 - 31 T) to describe a procedure which will insure the required accuracy for the measurements. It is accordingly recommended that this method be continued as tentative. A new method for determining the temperature coefficient of sheet resistance material is being developed. A method of determining the temperature coefficient of resistance of thermostatic metals is also being developed.

Subcommittee III on Chemical Analysis (T. R. Cunningham, chairman).—The Tentative Methods of Chemical Analysis of Metallic Materials for Electrical Heating (B 71 - 29 T) have been revised, the changes consisting principally of a different method of solution. Perchloric acid is used in place of nitro-hydrochloric acid in the chromium, iron, silicon and manganese determinations, providing a more rapid method without sacrificing accuracy. In the method for iron, a double separation with ammonium hydroxide is used. The ascarite absorption method replaces the volumetric method for carbon. The revised methods were presented to the Society through Committee E-10 on Standards and were accepted for publication as tentative[2] on March 8, 1933.

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[1] F. E. Bash and J. W. Harsch, "Life Tests on Metallic Resistor Materials for Electrical Heating," *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part II, p. 506 (1929).

[2] In submitting the revised tentative methods to Committee E-10 on Standards, the committee reported results of the letter ballot vote as follows: Of a total membership of 27, 17 members returned their ballots, of whom 14 voted affirmatively and none negatively.

Subcommittee IV on Mechanical Tests (P. H. Brace, chairman).—Negotiations are under way for the application of the bend test developed by Subcommittee IV to certain high-temperature alloys being studied by Committee III of the Joint Research Committee of the A.S.M.E. and A.S.T.M. on Effect of Temperature on the Properties of Metals. The bend test will be carried out by Subcommittee H on Elastic Measurement and Shear.

One laboratory has applied the bend test to the estimation of the properties of cast steel at high temperature with good results.

Subcommittee V on Wrought and Cast Alloys for High Temperature Use (C. L. Clark, chairman).—A method of test for the short-time tensile properties of cast alloys at temperatures from 800 to 2000 F. (425 to 1095 C.) has been outlined, including a suggested foundry procedure to insure sound castings. Good results have been secured with castings of a 35 per cent nickel, 20 per cent chromium, 45 per cent iron alloy and tests made by four laboratories at temperatures of 1400, 1600 and 1800 F. (760, 870 and 980 C.) show good agreement. This work is being carried on in cooperation with the Joint Research Committee on Effect of Temperature on the Properties of Metals. It is planned to merge the proposed short-time tension test with the proposed method for short-time high-temperature tension tests prepared by the Joint Committee.[1]

Further work has been done on the proposed method of test for thermal expansion, including also a design for a suitable quartz tube dilatometer and furnace. Two procedures with different rates of temperature change have been prepared.

Subcommittee VI on Specifications (J. W. Harsch, chairman).—Minor changes in the Tentative Specifications for Drawn or Rolled Alloy, 80 per cent Nickel, 20 per cent Chromium, for Electrical Heating Elements (B 82 - 31 T) and for Drawn or Rolled Alloy, 60 per cent Nickel, 15 per cent Chromium, and Balance Iron, for Electrical Heating Elements (B 83 - 31 T) have been considered and the specifications will be modified when they are recommended for advancement to standard. It is accordingly recommended that these specifications be continued as tentative pending their further consideration.

Subcommittee VII on Thermostatic Metals (P. H. Brace, chairman).—A study has been made of the various terms used in connection with thermostatic metals and considerable progress has been made in preparing definitions for them.

The first step in the development of methods of test has been the construction of apparatus for determining the bending properties of thermostatic metals under load and temperature. Apparatus for this purpose has been designed and built. The specimen is mounted so that the curvature with change of temperature can be accurately determined, the movement being highly magnified by the use of a light beam. Heat is applied externally. The equipment also provides for measuring the deflection under applied load. Therefore, it can be used to evaluate the resistance to applied stresses, simultaneously with or independently of measurements of deflections. It is also applicable to precise determination of elastic limit. It is planned to improve the mechanical design by cooperation between the laboratories and apply the device to the development of methods of test for mechanical properties and temperature sensitivity of thermostatic metals.

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[1] The Tentative Method of Test for Short-Time High-Temperature Tension Tests of Metallic Materials appears on p. 996.

This report has been submitted to letter ballot of the committee which consists of 26 members; 23 members returned their ballots, of whom 19 have voted affirmatively and none negatively.

Respectfully submitted on behalf of the committee,

DEAN HARVEY,
Chairman.

F. E. BASH,
Secretary.

EDITORIAL NOTE

The Tentative Accelerated Life Test for Metallic Materials for Electrical Heating and the Tentative Method of Test for Thermoelectric Power, as revised, were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1933. The methods in their revised form appear in the 1933 Book of A.S.T.M. Standards, Part I, pages 877 and 895, respectively.

REPORT OF COMMITTEE B-5

ON

COPPER AND COPPER ALLOYS, CAST AND WROUGHT

Committee B-5 has held two meetings during the past year; at Atlantic City, N. J., on June 24, 1932, and at New York City on March 9, 1933.

A revision of the Tentative Specifications for Sand Castings of the Alloy: Copper 80 per cent; Tin 10 per cent; Lead 10 per cent (B 74 – 28 T) and a corresponding revision affecting alloy No. 17 of the Tentative Specifications for Copper-Base Alloys in Ingot Form for Sand Castings (B 30 – 31 T) were presented to the Society through Committee E-10 on Standards and were accepted for publication[1] at a meeting held on August 11, 1932, at which Committee B-5 was represented by Mr. G. H. Clamer. As a result of this action the alloy in the form of castings in the one case and ingot metal in the other are identical in chemical composition. The tentative specifications in their revised form appear in the 1932 *Proceedings*.[2]

RECOMMENDATION AFFECTING STANDARDS

I. Advancement of Tentative Standards to Standard.—The committee recommends that the following two tentative specifications be advanced to standard, with revisions in the latter specifications as indicated below:

Tentative Specifications for Seamless Copper Tubing, Bright Annealed (B 68 – 32 T),[3] without revision.

Tentative Specifications for Copper Water Tube (B 88 – 32 T),[3] revised as follows:

Classes of Tubing.—Substitute throughout the specifications the letters K, L and M for the letters A, B and C to designate the different classes of copper tubing.

Section 7.—In view of the requirements for grain size in these specifications it is recommended that the following paragraph be added as Paragraph (*c*) of Section 7:

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[1] In submitting these revised tentative specifications to Committee E-10 on Standards, the committee reported results of the letter ballot vote as follows: Of a total membership of 50, 38 members returned their ballots, of whom 34 voted affirmatively and 1 negatively.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, pp. 670, 674 (1932); also 1932 Book of A.S.T.M. Tentative Standards, pp. 230, 234.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, pp. 679, 682 (1932); also 1932 Book of A.S.T.M. Tentative Standards, pp. 239, 242.

(*c*) In determining grain size, reference should be made to the standard rules governing the preparation of micrographs and photographic grain size standards for non-ferrous metals appearing in the Standard Rules Governing the Preparation of Micrographs of Metals and Alloys, Including Recommended Practice for Photography as Applied to Metallography (A.S.T.M. Designation: E 2) of the American Society for Testing Materials.

Table II.—For Class A (new Class K) tube 5 in. in nominal size, change the wall thickness from "0.148 in." to "0.160 in." and the corresponding weight per foot from "8.96 lb." to "9.67 lb."

For Class A (new Class K) tube 6 in. in nominal size, change the wall thickness from "0.165 in." to "0.192 in." and the corresponding weight per foot from "11.96 lb." to "13.87 lb."

For Class C (new Class M) tube 6 in. in nominal size, change the wall thickness from "0.120 in." to "0.122 in." and the corresponding weight per foot from "8.77 lb." to "8.91 lb."

II. Advancement of Tentative Revisions of Standards to Standard.—The committee recommends that the schedule of tolerances on length proposed in 1930[1] as a tentative revision of the three following standard specifications be advanced to standard and incorporated in the specifications:

Standard Specifications for Seamless Admiralty Condenser Tubes and Ferrule Stock (B 44 – 29)[2]

Standard Specifications for 70–30 Brass Condenser Tubes and Ferrule Stock (B 55 – 25)[2]

Standard Specifications for Seamless Muntz Metal Condenser Tubes and Ferrule Stock (B 56 – 25)[2]

The committee recommends that the tentative revision of the following four standard specifications published in the 1932 report[3] of this committee, proposing that the requirement for copper plus silver content of the copper plates, bars, tubes and pipe be increased from "99.88 per cent" to "99.90 per cent," be advanced to standard and incorporated in the specifications:

Standard Specifications for Copper Plates for Locomotive Fire Boxes (B 11 – 18)[4]

Standard Specifications for Copper Bars for Locomotive Staybolts (B 12 – 21)[4]

Standard Specifications for Seamless Copper Boiler Tubes (B 13 – 18)[4]

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, pp. 408, 1272 (1930); also 1932 Book of A.S.T.M. Tentative Standards, p. 1134.

[2] 1930 Book of A.S.T.M. Standards, Part I, pp. 729, 733, 737.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, pp. 256, 987, 988 (1932); also 1932 Book of A.S.T.M. Tentative Standards, pp. 1131, 1132.

[4] 1930 Book of A.S.T.M. Standards, Part I, pp. 715, 718, 721.

Standard Specifications for Copper Pipe, Standard Sizes (B 42 – 24)[1]

The committee recommends that the tentative revision of the last named specifications (B 42 – 24), also published in the 1932 report,[2] proposing that the first sentence in Paragraph (*a*) of Section 12 be omitted, be advanced to standard.

The committee recommends that the rather extensive tentative revisions of the following two standard specifications proposed in 1932[3] be advanced to standard with a minor editorial revision in the latter standard, as indicated below:

Standard Specifications for Brass Pipe, Standard Sizes (B 43 – 24)[4]

Standard Specifications for Sheet High Brass (B 36 – 27)[4] revised as follows:

Section 10.—Make the footnote to the revised Section 10 a new paragraph to read as follows:

> In determining grain size, reference should be made to the standard rules governing the preparation of micrographs and photographic grain size standards for brass appearing in the Standard Rules Governing the Preparation of Micrographs of Metals and Alloys, Including Recommended Practice for Photography as Applied to Metallography (A.S.T.M. Designation: E 2) of the American Society for Testing Materials.

III. Editorial Revision of Standards.—The committee has authorized making an editorial change in the drawing of the die block appearing in the following four standard specifications which will be in conformity with a similar revision in the steel specifications providing that the design of the die block used for making flange tests on tubes and pipe be modified by the addition of a radius of $\frac{1}{32}$ in. at the top instead of a sharp shoulder as heretofore:

Standard Specifications for Seamless Copper Boiler Tubes (B 13 – 18)[5]

Standard Specifications for Seamless Brass Boiler Tubes (B 14 – 18)[5]

Standard Specifications for Copper Pipe, Standard Sizes (B 42 – 24)[5]

Standard Specifications for Seamless Copper Tubes (B 75 – 30)[5]

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 743.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, pp. 256, 987, 988 (1932); also 1932 Book of A.S.T.M. Tentative Standards, pp. 1131, 1132.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, pp. 256, 258 (1932); also 1932 Book of A.S.T.M. Tentative Standards, pp. 1132, 1135.

[4] 1930 Book of A.S.T.M. Standards, Part I, pp. 747, 768.

[5] 1930 Book of A.S.T.M. Standards, Part I, pp. 721, 725, 743, 751.

ACTIVITIES OF SUBCOMMITTEES

Subcommittee I on Wrought Metals and Alloys (D. K. Crampton, chairman).—This subcommittee is engaged in the preparation of specifications covering high-strength silicon-copper alloys and for rolled phosphor-bronze bearing plates for movable bridges, the latter in cooperation with a committee of the American Railway Association.

Subcommittee II on Cast Metals and Alloys (G. H. Clamer, acting chairman).—This subcommittee is engaged in a general program of correlating specifications for ingot metal and sand castings.

The above recommendations have been submitted to letter ballot of the committee, with the following results:

Items	Affirmative	Negative	Not Voting
I. ADVANCEMENT OF TENTATIVE STANDARDS TO STANDARD			
Specifications for Seamless Copper Tubing, Bright Annealed (B 68 – 32 T)	26	0	8
Specifications for Copper Water Tube (B 88 – 32 T), as revised	27	0	9
II. ADVANCEMENT OF TENTATIVE REVISIONS OF STANDARDS TO STANDARD			
Specifications for Seamless Admiralty Condenser Tubes and Ferrule Stock (B 44 – 29)	28	0	8
Specifications for 70–30 Brass Condenser Tubes and Ferrule Stock (B 55 – 25)	28	0	8
Specifications for Seamless Muntz Metal Condenser Tubes and Ferrule Stock (B 56 – 25)	27	0	9
Specifications for Copper Plates for Locomotive Fire Boxes (B 11 – 18)	22	0	14
Specifications for Copper Bars for Locomotive Staybolts (B 12 – 21)	22	0	14
Specifications for Seamless Copper Boiler Tubes (B 13 – 18)	25	0	11
Specifications for Copper Pipe, Standard Sizes (B 42 – 24)	31	0	5
Specifications for Brass Pipe, Standard Sizes (B 43 – 24)	29	0	7
Specifications for Sheet High Brass (B 36 – 27)	26	0	10

This report has been submitted to letter ballot of the committee, which consists of 52 members; 44 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

C. H. MATHEWSON,
Chairman.

D. K. CRAMPTON,
Secretary.

EDITORIAL NOTE

The Tentative Specifications for Seamless Copper Tubing, Bright Annealed, without revision, and the Tentative Specifications for Copper Water Tube, as revised, were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1933, and appear in the 1933 Book of A.S.T.M. Standards, Part I, pages 743 and 734, respectively.

The tentative revisions of the Standard Specifications for Seamless Admiralty Condenser Tubes and Ferrule Stock, for 70-30 Brass Condenser Tubes and Ferrule Stock, for Seamless Muntz Metal Condenser Tubes and Ferrule Stock, for Copper Plates for Locomotive Fire Boxes, for Copper Bars for Locomotive Staybolts, for Seamless Copper Boiler Tubes, for Copper Pipe, Standard Sizes, for Brass Pipe, Standard Sizes, and for Sheet High Brass were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1933. The specifications in their revised form appear in the 1933 Book of A.S.T.M. Standards, Part I, pages 693, 697, 701, 713, 676, 679, 705, 709, and 728, respectively.

REPORT OF COMMITTEE B-6
ON
DIE-CAST METALS AND ALLOYS

Committee B-6 on Die-Cast Metals and Alloys has held two well attended meetings during the year: one in Atlantic City, N. J., on June 23, 1932, and the other in New York City on February 23, 1933.

The committee has added one new member, Mr. C. E. Heussner, representing the Chrysler Corporation, and has lost through termination of Society membership, Messrs. A. G. Carman, F. S. Elfred, Jr., R. L. Johnston, M. C. Maxwell and F. J. Tobias. In view of the extensive contributions of several of these men to the earlier work of the committee, suitable action has been taken toward keeping them advised of activities through periodic bulletins, pending their reinstatement as members. Mr. C. R. Maxon has been appointed as the committee representative on the general membership committee and is actively engaged in publicizing the committee's work and soliciting new members.

RECOMMENDATIONS AFFECTING STANDARDS

Revisions of Tentative Standards.—The committee recommends that the following tentative specifications be revised as explained in the reports of the respective subcommittees and continued as tentative:

Tentative Specifications for Aluminum-Base Alloy Die Castings (B 85 – 31 T), as proposed by Subcommittee I;

Tentative Specifications for Zinc-Base Alloy Die Castings (B 86 – 31 T), as proposed by Subcommittee II.

The above recommendations have been submitted to letter ballot of the committee, which consists of 54 members, with the following results:

Items	Affirmative	Negative	Not Voting
I. REVISIONS OF TENTATIVE STANDARDS			
Specifications for Aluminum-Base Alloy Die Castings (B 85 – 31 T)	33	1	3
Specifications for Zinc-Base Alloy Die Castings (B 86 – 31 T)	31	3	3

ACTIVITIES OF SUBCOMMITTEES

Subcommittee I on Aluminum-Base Die-Casting Alloys (E. E. Thum, chairman).—This subcommittee recommends that the Tentative Specifications for Aluminum-Base Alloy Die Castings (B 85 – 31 T)[1] be revised, as indicated below, and continued as tentative:

Table I.—In Table I of these specifications, change the chemical composition of alloy No. XII by decreasing the permissible range in copper content from "7.0 to 9.0 per cent" to read "6.0 to 8.0 per cent;" and by increasing the permissible variation in silicon content from a range of "1.0 to 2.0 per cent" to read "3.5 per cent, maximum;" also under other elements, maximum, increase the zinc content from "1.0 per cent" to read "1.5 per cent."

In the table appearing in the appendix to these specifications, omit the tensile strength value of 33,000 lb. per sq. in., the elongation in 2 in. of 1.0 per cent, and the Charpy impact value of 1.5 ft-lb. for alloy No. XII.

In considering and approving these changes, the committee took cognizance of the fact that in general commercial practice the copper, silicon, and zinc contents approximate more closely to the new limits and that this alloy is essentially a competitive composition (without specified physical or corrosion-resistant properties).

Subcommittee II on Zinc-Base Die-Casting Alloys (W. H. Graves, chairman).—This subcommittee has been the most active one during the past year and has largely rewritten the Tentative Specifications for Zinc-Base Alloy Die Castings (B 86 – 31 T)[2], as shown in the revised draft appended hereto.[3] The revised specifications were drafted by the subcommittee at a meeting in Detroit on January 25, 1933, and were adopted by Committee B-6 at its February, 1933, meeting, subject to a favorable letter ballot, with one change, namely, the elimination of maximum total other impurities.

Since the committee first undertook an investigation of zinc-base die-casting alloys, new alloys have been developed and introduced commercially. Because of several advantages which alloy No. XXIII possesses over alloy No. XXI,[4] it has been commercially adopted for numerous new uses. This has led to definite requests to both the Society of Automotive Engineers and to Committee B-6 that specifications covering alloy No. XXIII be prepared. This alloy had been investigated quite thoroughly by several laboratories willing to discuss their results with the committee and the necessary information on which to base a specification was therefore available.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 716 (1931); also 1932 Book of A.S.T.M. Tentative Standards, p. 292.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 719 (1931); also 1932 Book of A.S.T.M. Tentative Standards, p. 295.

[3] See p. 644.—ED.

[4] This alloy designation corresponds to the number used in the investigation on zinc-base die-casting alloys carried out under the jurisdiction of Committee B-6 on Die-Cast Metals and Alloys (formerly Subcommittee XV on Die-Cast Metals and Alloys of Committee B-2 on Non-Ferrous Metals and Alloys). See *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 192 (1929).

Briefly, the essential difference between alloy No. XXI, at present specified in the Tentative Specifications B 86 - 31 T, and the new alloy No. XXIII is that alloy No. XXIII undergoes a much smaller dimensional change as the result of aging changes other than those due to any type of oxidation, and that even the slight aging changes which occur may be prevented by a simple stabilizing anneal. In addition, alloy No. XXIII, like alloy No. XXI, has a high initial impact strength but unlike alloy No. XXI, it retains this impact strength under severe and varied conditions of aging.

It has been amply shown that the resistance of both alloys to abnormal oxidation depends on the careful limitation of the impurities, lead, cadmium and tin. The amounts which have been set as the specification limits are low enough to produce alloys meeting the rather severe physical property requirements of the specification and at the same time no undue hardship is imposed on the producer since several sources of raw materials of adequate purity are available and it has been demonstrated that by good control of alloying and casting practice, contamination beyond these limits can be avoided commercially.

While iron has no injurious effect on the physical properties of these alloys, it is the general belief that an iron content above that specified may cause trouble in machining. The limit specified may be easily maintained because of the well known self-scavenging properties of the zinc-aluminum alloys with respect to iron.

It is known that the absence of aging changes in alloy No. XXIII as compared to alloy No. XXI is due to the difference in copper content. The committee was assured that sufficient tests had been made to make it certain that amounts of copper up to 0.1 per cent are entirely harmless. It was the belief of the committee that contamination of this alloy with copper beyond this limit could be avoided commercially.

The physical property requirements of alloy No. XXI were based on the data of Committee B-6. The physical property limits established for alloy No. XXIII were based on data agreed to by several members of the committee representing laboratories which had independently determined the properties for alloy No. XXIII. In the case of both alloys, due regard was given both to the interests of the consumer in setting these values high enough to exclude material not representative of what can be attained with good commercial practice and, at the same time, to the interests of the producer in avoiding too rigid requirements which would reject material coming within the range of good average commercial practice.

Changes made in alloy No. XXI, heretofore covered by Tentative Specifications B 86 – 31 T, include a lowering of the maximum limit on magnesium and lead, which changes have been shown by commercial use to be possible of realization without undue hardship on the producer. The maximum limit on total other impurities was eliminated because of its ambiguity and the impossibility of checking for all other elements in the periodic system in a commercial chemical analysis. Although it is recognized that the presence of such elements as bismuth and mercury are detrimental in high quality zinc-base die castings, their rarity in the commercial alloy made it unnecessary to specify maximum limits in the opinion of the committee. The presence of silicon in the form of silica is also disadvantageous from a machining standpoint, but it was decided not to place any maximum limit on it at this time.

The requirement that the measurement of expansion in a humidity test must be across solid sections of the casting was shown to be necessary by an occasional tendency of a consumer to measure this value across the lips of a cup-shaped piece in which accidental distortion was found to exercise too large an influence. The other changes in wording represent the clarification of sections capable of misinterpretation in the present tentative specifications.

Subcommittee V on Exposure and Corrosion Tests (W. M. Peirce, chairman).—All of the data on the one-year exposure tests are now available excepting those for the physical properties of the specimens from Coco Solo, Panama Canal Zone. It is too late now to have these specimens tested, since they have suffered two years of northern exposure in addition to the one-year exposure at the Coco Solo test location. The subcommittee felt that the three-year specimens should be left exposed until the five-year period is completed, because considerable difficulty would be encountered in finding a sufficient number of testing laboratories to test all of the specimens at the present time. While all of the zinc-base alloy specimens will be returned after five years, only alloys Nos. XV, XVI and XXI will be tested. All of the other alloys are now obsolete and the only advantage to be gained by testing alloys Nos. XV and XVI would be to further substantiate the effect of impurities on permanence as already shown by the steam test and practical experience.

Subcommittee VI on Finishing Properties of Die Castings (J. C. Fox, chairman).—Although it has not been found possible to hold a meeting of this subcommittee during the year, the chairman has continued his studies on the finishing of die castings and particularly of electroplated coatings. The discussion to which reference was made in last year's report[1] has been supplemented by data obtained from further studies in which various companies have cooperated. It is hoped to have the material in shape for an official report at a later date.

Special Subcommittee on Analysis of Test Data (R. G. Roshong, chairman).—By action of Committee B-6 at its June, 1932, meeting this special subcommittee was created to determine a basis for acceptance or rejection of test data obtained by cooperating laboratories on committee specimens and, in particular, to pass on the desirability of publishing certain specific groups of data. In this connection, it is worthy of note that less than 5 per cent of the data on physical properties of aluminum-base and zinc-base die-cast specimens, which has been collected by the committee and circulated to all its members, has ever been published in the *Proceedings* of this Society. A considerable portion of these data apply to alloys differing from those since standardized in the Tentative Specifications B 85 and B 86, but the subcommittee recommended that the only data to be published *in extenso* in the *Proceedings* in the future should be those obtained on specimens conforming to the latest revised alloy compositions in Specifications B 85 or B 86.

Consideration was also given to the desirability of further analyses of the available data either similar to the discussions presented by Mr. Colwell[2] in 1931 and by Mr. Field[3] in 1932, or conforming more closely to the statistical methods outlined in the 1931 report of the Technical Committee on Presentation of Data of Committee E-1 on Methods of Testing.[4] While the committee felt themselves to be handicapped by their limited acquaintance with the newer statistical methods, they agreed that the form in which the data have been presented to date has been very useful to the designer of die-cast parts, particularly since the data have been compactly rearranged by the Bell Telephone Laboratories and copies circulated to the committee members.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 268 (1932).

[2] D. L. Colwell, "Effect of Composition on Aluminum-Base Die-Casting Alloys," *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 268 (1931).

[3] A. J. Field, "The Physical Properties of Aluminum-Base Die-Casting Alloys," *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 285 (1932).

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 593 (1931).

It was the consensus of opinion in the committee that (1) the needs of consumers and designers of die castings were adequately served by a statement of maximum, minimum and arithmetical averages of physical properties; (2) the variables incident to the various methods of producing the test specimens, such as casting pressure, die temperature, venting, etc., were of such magnitude (and uncertainty at this time) as to render the applicability of statistical analysis questionable; and that (3) any analysis of the results on test specimens would be of questionable value in designing or accepting die castings, inasmuch as each type of die casting is an individual problem as regards density, chilling, and flow in various sections of the casting, all of which have definite effects on the resultant physical properties. It was, therefore, decided that further published studies of committee data would be limited to results on standardized compositions as noted above and that no organized attempt would be sponsored by the committee to undertake a general statistical analysis of its data.

The subcommittee recommended further that pending tests on aluminum-base die-casting specimens which have been exposed at ten locations in the United States since July, 1929 (see previous committee reports)[1] should be carried out on alloys Nos. I to XII, inclusive, at the end of the five-year exposure period. Tests on all exposed aluminum specimens appear justified in view of the practical value of the evidence to be obtained regarding the effects of excess iron, tin, lead, etc., on the atmospheric corrosion. In line with the above action on data collected previously, the new data on specimens not conforming to the limits of the Tentative Specifications B 85 shall be circulated only to the membership of Committee B-6 in view of the unfavorable reaction which might result from publication of results on compositions known to be inferior to those standardized.

In view of the obsolescence of such a large share of the zinc-base alloys included in the committee's original program, as stated under Subcommittee II, above, it was recommended that only alloys Nos. XV, XVI and XXI should be brought in from exposure racks at the end of the five-year period for complete testing. These alloys are representative of the nominal composition, copper 3 per cent, aluminum 4 per cent, magnesium 0.1 per cent, zinc, balance, with impurities varying according to the purity of zinc used.

New Subcommittee.—Committee B-6 is following closely the developments in other die-casting alloys and receives progress reports periodically on the brass- and magnesium-base alloys. As a matter of information, Mr. J. A. Gann submitted a preliminary draft of specifications for a magnesium-base alloy at the New York meeting of the committee in February. This alloy is made to the following composition limits:

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[1] **Reports on Die-Cast Metals and Alloys, see *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 202 (1928); Vol. 29, Part I, p. 192 (1929); Vol. 30, Part I, p. 318 (1930); Vol. 31, Part I, p. 261 (1931); Vol. 32, Part I, p. 264 (1932).**

Magnesium, min., per cent	88.0
Aluminum, per cent	9.5 to 10.5
Manganese, min., per cent	0.1
Copper, max., per cent	0.1

The following physical properties can be expected of tension and impact specimens of this analysis when made in a die, the test specimens being cast in regular production routine and conforming to the dimensions of Figs. 1 and 2 of the Tentative Specifications for Zinc-Base Alloy Die Castings (B 86 – 31 T).[1] The values are for die-cast test specimens and not for specimens cut from commercial die-cast parts.

DIE-CASTING METHOD	TENSILE STRENGTH, LB. PER SQ. IN.	ELONGATION IN 2 IN., PER CENT	CHARPY IMPACT VALUE, FT-LB.
Low Pressure	26 000 to 30 000	1 to 3	1 to 3
High Pressure	29 000 to 33 000	1 to 3	1 to 2

Committee B 6 has authorized the formation of a new Subcommittee on Magnesium-Base Die-Casting Alloys to consider the standardization of suitable alloys.

This report has been submitted to letter ballot of the committee which consists of 54 members; 37 members returned their ballots, of whom 34 have voted affirmatively and 1 negatively.

Respectfully submitted on behalf of the committee,

H. A. ANDERSON,
Chairman.

P. V. FARAGHER,
Secretary.

EDITORIAL NOTE

The proposed revisions of the Tentative Specifications for Aluminum-Base Alloy Die Castings and for Zinc-Base Alloy Die Castings were accepted. The specifications in their revised form appear on pages 641 and 644, respectively.

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[1] See p. 644.—ED.

REPORT OF COMMITTEE C-1

ON

CEMENT

Committee C-1 on Cement has held only one meeting since the 1932 annual meeting of the Society. However, that meeting, on January 23, 1933, was well attended and in spite of adverse business conditions the committee has maintained considerable activity during the year.

An important action at the January meeting was the adoption of a plan of reorganization of the committee. The purpose of this reorganization was to simplify the committee make-up and facilitate operation by replacing the large subcommittees and their sections by smaller groups, arranged so as to prevent, as far as possible, duplication of effort. Briefly, the plan provided that the Executive Committee of Committee C-1 should appoint a number of sponsoring committees, each to consist of four members, and each committee to have charge of one of the existing cement specifications under the jurisdiction of Committee C-1. Other sponsoring committees are to be similarly appointed as found advisable. The Executive Committee was also to appoint, from time to time, working committees of three members each, to work on problems assigned to them. These working committees are to be supervised by and will report to the Executive Committee of Committee C-1. Part of the reorganization has been already effected and further changes will be made from time to time.

ACTIVITIES OF SUBCOMMITTEES

Since the June, 1932, meeting there have been summarized the results of work started in the preceding year in the study of a proposed plastic mortar compressive strength test for the high-early-strength cements. This work has been carried out under the supervision of Subcommittee C on Specifications for High-Early-Strength Cement. Twelve laboratories participated in the investigation in which six cements were employed. Two-inch cubes of the plastic mortar as well as standard tension specimens were made and tested at 1, 3, 7 and 28 days. After considerable study of the results of these tests, there was outlined a further program of investigation which has been already started and involves 12 cements. Eleven laboratories are participating in these tests in cooperation with the new working committee to which has been assigned the study of the possibilities of plastic mortar strength tests.

Section III on Study of Accelerators and Retarders of Subcommittee B on Specifications for Portland Cement has just completed a lengthy report for presentation to the Executive Committee of Committee C-1, covering the recent studies in three laboratories on the effect of varying SO_3 content on a number of cements of different tricalcium aluminate content. The program included tests for setting time, tensile strength of mortars, compressive strength of concrete, volume change of concrete and the resistance of the concrete to freezing and thawing. Some of the test results already obtained include ages up to six months.

Mr. J. R. Dwyer, the Technical Assistant of the committee, has continued his efforts to maintain contact between the committee and parties interested in cement specification questions, and has cared for many of the details of the committee work. In the interest of uniformity of test methods, he attended a meeting of the American Association of State Highway Officials, at which meeting there were discussed some questions relating to the current A.S.T.M. Standard Methods of Sampling and Testing Portland Cement (C 77 – 32). The A.A.S.H.O. had previously adopted as their Tentative Method T-1 the A.S.T.M. methods which formerly appeared in the Standard Specifications for Portland Cement (C 9 – 30). Visits were made to the Department of Highways of Chautauqua County, N. Y., and to the Boston Transit Department in order to secure data and comments relating to their special requirements for portland cement. Information thus obtained was distributed to the committee. Additional data of interest are being made available by another state highway department. Visits were also made to some offices of both producer and non-producer interests. Mr. Dwyer has continued the general direction of the Cement Reference Laboratory and has maintained contact with the meetings of committees and groups engaged in activities of interest to the membership of Committee C-1.

The Cement Reference Laboratory, a cooperative project of the U. S. Bureau of Standards and the Society, partly financed by Committee C-1, has continued the field inspections of laboratories and has completed the major portion of a third tour. In addition to the field work, the laboratory has studied fineness test methods in the endeavor to arrive at a rapid and economical method of determining the sub-sieve fineness of cement. The laboratory has worked quite effectively in recent months in developing a new turbidimetric method of dealing with the fineness of sub-sieve cement particles. The laboratory also arranged for a series of comparative fineness tests by a number of laboratories in order to obtain some definite knowledge of the agreement which might exist in the sub-sieve fineness determinations made by different laboratories and with different apparatus.

Appended hereto is a report of the Subcommittee on Cement Reference Laboratory which describes the laboratory's activities since the date of preparation of the 1932 annual report. There is being presented at this annual meeting a paper by Mr. L. A. Wagner of the Cement Reference Laboratory describing the turbidimeter fineness test method as thus far developed.[1]

The committee suffered the loss of a very valuable and well liked member in the death of Mr. Frederick W. Kelley. Mr. Kelley has long been very prominent in promoting and supporting committee activities, and was particularly active in the arrangements for the establishment and maintenance of the Cement Reference Laboratory.

RECOMMENDATIONS AFFECTING STANDARDS

The committee recommends that the Tentative Specifications for High-Early-Strength Portland Cement (C 74 - 30 T)[2] be referred to letter ballot of the Society for adoption as standard. This recommendation has been submitted to letter ballot of the committee, which consists of 67 members; 43 members returned their ballots, of whom 31 have voted affirmatively, 10 negatively and 2 marked their ballots not voting.

The committee recommends that the Tentative Specifications and Tests for Masonry Cement (C 91 - 32 T)[3] be continued as tentative for another year without revision.

This report has been submitted to letter ballot of the committee which consists of 67 members; 55 members returned their ballots, of whom 53 have voted affirmatively and none negatively.

Respectfully submitted on behalf of the committee,

P. H. BATES,
Chairman.

G. A. SAEGER,
Secretary.

EDITORIAL NOTE

The Tentative Specifications for High-Early-Strength Portland Cement, recommended for adoption as standard, failed to receive the necessary two-thirds vote of those voting when this recommendation was presented to the Society at the annual meeting. The specifications are accordingly continued as tentative.

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[1] L. A. Wagner, "A Rapid Method for the Determination of the Specific Surface of Portland Cement," *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part II, p. 553 (1933).

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 1016 (1930); also 1932 Book of A.S.T.M. Tentative Standards, p. 335.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 695 (1932); also 1932 Book of A.S.T.M. Tentative Standards, p. 338.

REPORT OF SUBCOMMITTEE ON CEMENT REFERENCE LABORATORY

The Cement Reference Laboratory completed the second inspection tour among cement testing laboratories shortly after the date of preparation, March 17, 1932, of the preceding annual report of this subcommittee. A few requested inspections were left unperformed because the inspectors had passed through the territories involved before these requests had been received. Subsequently there was announced a third inspection tour, which is now in progress and which is about 50 per cent completed. Since the end of the second tour there have been received requests for inspections of 232 laboratories distributed over 44 states. The classification of these laboratories is shown in Table I. The decrease in requests received in the third tour from the number of requests involved in the second tour is partly accounted for by the fact that some of the laboratories visited in the earlier inspection were closed when their districts were recently visited. Also, it is probable that the decrease is due in some measure to the insistence on the part of the Reference Laboratory that, in general, reinspections would not be made in laboratories which in earlier tours had been found considerably deficient until such time as those laboratories gave some assurance that an effort had been made to remedy the deficiencies. Automatic temperature control storage apparatus has not been made a requirement for inspections because of the business conditions existing during recent months, but the reports have stressed the need of close attention to storage temperatures.

There is still in effect the ruling of the U. S. Bureau of Public Roads requiring Cement Reference Laboratory inspection at all laboratories issuing reports of acceptance tests intended for Federal Aid road projects. Copies of reports of inspections of the various laboratories affected by this ruling have been furnished to the Bureau of Public Roads and state highway offices.

While no attempt has yet been made to summarize many of the details of the reports of inspections made during recent months, it appears that there has been a considerable improvement in methods. The quantities of apparatus inspected and approved during the period covered by this report are shown in Table II. Only a small quantity of this apparatus was involved in the second inspection tour. A comparison of this table with the corresponding table in the preceding annual report of this subcommittee[1] indicates a general improvement also in apparatus. However, some of this general improvement in apparatus may be due to elimination of certain laboratories which did not feel warranted in making the improvements justifying a reinspection and also to the fact that the tolerances for briquet molds have been made somewhat more lenient. Some laboratories have itemized in their correspondence the improvements made by them since their last inspection.

Table I.—Classification of Cement Testing Laboratories Requesting Inspections.

Laboratory Classification	First Tour, Up to November 30, 1930	Second Tour, December 1, 1930, to April 16, 1932	Third Tour (in Progress), April 17, 1932, to February 28, 1933	Participating in Third Tour and in One Earlier Tour	Participating in Three Tours
Producer	106	114	99	90	56
Commercial[a]	49	52	42	37	22
State Highway[a,b]	23	61	58	49	21
Schools	25	34	19	16	2
Municipal	11	11	7	6	3
Miscellaneous	5	5	7	7	5
Total	219	277	232	205	109
Canceled[c] (included in total)	7	7	17[d]		

[a] Some branch laboratories are located at producers' laboratories.
[b] In some cases the highway laboratories are also school laboratories.
[c] Canceled or indefinitely postponed.
[d] State Highway 5, Producers 2, Commercial 10.

Table II.—Apparatus Inspected from March 18, 1932, to February 28, 1933.

Apparatus	Number Observed	Number Approved[a]
Steam chests	116	96
Balances for fineness	118	84
Balances for mixes	172	146
Weights for fineness, pieces	1504	1477
Graduates and burettes	358	334
Weights for mixes, pieces	1681	1637
Vicat apparatus	149	114
Gillmore needles, pairs	148	130
Briquet molds	5394	4888
Tension testing machines	124	97
Total	9764	9003

[a] A small portion of this apparatus was tested under the requirements in effect prior to the adoption in 1932 of the Standard Methods of Sampling and Testing Portland Cement (C 77 – 32).

The study of the methods of determining the fineness of cement was continued throughout the year in the Bureau of Standards' laboratory. As a result of this work there has been developed a turbidimetric test[1] which was discussed and demonstrated at the meeting of Committee C-1 on January 23, 1933. Comparisons of the turbidimetric test results with the results obtained by other methods indicate that, as now developed, the method is particularly interesting to producer laboratories. A number of laboratories have either constructed turbidimeters for themselves or are planning to purchase the apparatus required for this test.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 314 (1932).

The Reference Laboratory prepared three samples for comparative fineness tests by various laboratories cooperating with the Bureau of Standards in securing data showing what agreement in results might be obtained by various fineness test methods. These results are being furnished to the participating laboratories together with a summary of the more important items of interest relating to the work. The report and information growing out of the work is also being made available to the Subcommittee on Fineness, of Committee C-1.

The laboratory has cooperated with the committee in exchanging information relating to methods and apparatus. Assistance was given to the Subcommittee on Apparatus in preparing the manuscript of the revised Manual of Cement Testing presented last year. The laboratory also promoted discussion on the question of the rate of loading for compression specimens, and hopes to secure more data on this subject.

Information has been furnished in reply to inquiries from various laboratories concerning improvement or replacement of apparatus. The laboratory has also discussed with producers of equipment some questions relating to specifications and design of apparatus.

The laboratory cooperated with the Subcommittee on High-Early-Strength Cement and participated, with eleven other laboratories, in a series of tests sponsored by that subcommittee in a study of a proposed plastic mortar strength test.

Respectfully submitted on behalf of the subcommittee,

C. F. CONN,
Chairman.

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[1] L. A. Wagner, "A Rapid Method for the Determination of the Specific Surface of Portland Cement," *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part II, p. 553 (1933).

REPORT OF COMMITTEE C-5

ON

FIRE TESTS OF MATERIALS AND CONSTRUCTION

Since reporting to the Society at the annual meeting in June, 1932, Committee C-5 and its subcommittees, with the exception of Subcommittee I on Standard Specifications for Fire Tests of Materials and Construction (S. H. Ingberg, chairman), have found it impracticable to make substantial progress on their various scheduled subjects because of generally unfavorable economic conditions.

RECOMMENDATIONS AFFECTING STANDARDS

Tentative Specifications for Fire Tests of Building Construction and Materials (*C 19 – 26 T*).[1]—Subcommittee I has given attention to comments received during the past few years on the Tentative Specifications for Fire Tests of Building Construction and Materials (C 19 – 26 T) and recommended to Committee C-5 at a meeting called for the purpose in New York City on March 10, 1933, that these specifications be revised as follows and adopted as standard:

Introduction.—Change the last paragraph of the introductory text to read as follows by the addition of the italicized words and the omission of those in brackets:

> Classifications of assemblies involving combustibles in [sufficient] *such kind or* quantity or so [arranged as to continue burning after the derived time period] *contained as to burn freely during the exposure to the test fire or continue flaming after the furnace fire is shut off* shall be designated by the term "combustible" after the period assigned.

Section 2.—In the time-temperature tabulation in this section change the expression in the last line of the table from "at 8 hours" to read "at 8 hours or over." The words "or over" are added to indicate that in tests of more than 8 hours duration temperatures are to be held at 2300 F. (1260 C.) after the eighth hour; it is judged unnecessary to illustrate this additional feature by extending the chart of the time-temperature curve shown in Fig. 1 of the specifications.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 761 (1926); also 1932 Book of A.S.T.M. Tentative Standards, p. 458.

The Centigrade temperatures 1010 C. and 1260 C. are exact equivalents of the Fahrenheit temperatures 1850 F. and 2300 F., respectively, and the omission of the word "approximately" used in connection with these temperatures is accordingly recommended.

Section 4 (a).—Change the first sentence of this section to read as follows by the addition of the italicized words and the omission of those in brackets and insert the italicized sentence as the second sentence of the section:

> Temperatures at unexposed surfaces shall be measured with thermocouples or thermometers placed under *flexible*, oven-dry, *felted* asbestos [fire felt] pads 6 in. square, 0.4 in. [thick] *in thickness*, and weighing not less than 1.0 [lb. per sq. ft.] nor more than 1.4 lb. per sq. ft. *The pads shall be sufficiently soft so that, without breaking, they may be shaped to contact over the whole surface against which they are placed.*

Section 7.—Change the first sentence of this section to read as follows by the addition of the italicized words:

> The test sample shall be truly representative of the construction for which classification is desired *as to materials, workmanship, and details such as dimensions of parts*, and shall be built under conditions representative of those obtaining as practically applied in building construction *and operation*.

Section 9.—In Paragraphs (*a*) and (*b*) of this section substitute for "fire hose stream" the expression "hose stream."

Change Paragraph (*c*) to read as follows by the omission of the words in brackets:

> (*c*) The submitter may elect, with the advice and consent of the testing body, to have the [fire] hose stream test made on the sample subjected to the fire endurance test and immediately following the expiration of the fire endurance test [provided, that the testing body reserves the right to decide that a fire hose stream test should be made on a duplicate sample as specified in Paragraph (*a*)].

Section 10.—Change the second sentence of this section to read as follows by the addition of the italicized words and the omission of the words and figures in brackets:

> [Where this cannot be attained within 40 days] Artificial drying [with air temperature not exceeding 100 F. (38 C.) shall] *at temperatures not injurious to the material or construction to be tested may* be used.

Section 12.—In this section substitute for "fire stream tests" the expression "hose stream tests."

Section 13 (b).—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

> (*b*) The wall or partition shall have sustained the applied load during the fire and [fire] *hose* stream test as specified in Section 9, without passage of flame, [stream or] *of* gases hot enough to ignite cotton waste, *or of the hose stream*, and after cooling but within 72 hours after its completion shall sustain a total load equal to the dead load plus twice the superimposed load specified above.

Section 15 (*b*).—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

(*b*) The wall or partition shall have withstood the fire and [fire] *hose* stream test as specified in Section 9, without passage of flame, [stream or] *of* gases hot enough to ignite cotton waste, *or of the hose stream.*

Section 17 (*a*).—Change the first sentence of this section to read as follows by the addition of the italicized words:

During the fire endurance test the column *shall be exposed to fire on all sides and* shall be loaded in a manner calculated to develop theoretically as nearly as practicable the working stresses contemplated by the design.

Section 21 (*b*).—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

(*b*) The construction shall have sustained the applied load during the fire and [fire] *hose* stream test as specified in Section 9, without passage of flame, [stream or] *of* gases hot enough to ignite cotton waste, *or of the hose stream,* and after cooling but within 72 hours after its completion shall sustain a total load equal to the dead load plus twice the superimposed load specified above.

Chapter X.—Change the title to read as follows by the addition of the italicized words:

X. Tests of Finish for *Combustible Framing or Facings of* Walls, Partitions and Ceilings

Section 22.—In the expression "with respect to panels of solid or masonry construction" appearing at the end of Paragraphs (*a*), (*b*) and (*c*) of this section, omit the phrase "or masonry."

Section 24.—Change Paragraphs (*a*) and (*b*) of this section to read as follows by the addition of the italicized words and the omission of those in brackets:

(*a*) The finish shall have withstood the fire endurance test without [developing openings capable of passing] *passage of* flame or [hot] *of* gases *hot enough to ignite the materials protected,* for a period equal to that for which classification is desired.

(*b*) The finish shall have withstood the fire and [fire] *hose* stream test as prescribed respectively for floors, walls and partitions as specified in Section 9, without [developing openings capable of passing] *passage of* flame, [hot] *of* gases *hot enough to ignite the materials protected,* or *of the hose* stream.

The above recommendation and the proposed revisions of the Tentative Specifications C 19 – 26 T have been submitted to letter ballot of Committee C-5, consisting of 28 members, and have been voted upon affirmatively by more than the requisite two thirds of those voting. Twenty-seven members returned their ballots, of whom 21 have voted affirmatively on all the items, and none has voted negatively on all the items; of the remaining six, one has cast no negative votes but has registered as "not voting" on certain items; and of the remaining five who have voted negatively on certain items, none has voted negatively on more than three of the items; and none of the items submitted for ballot has received more than four negative votes.

The foregoing revisions have also been submitted to letter ballot of the Sectional Committee on Specifications for Fire Tests of Materials and Construction, functioning under the procedure of the American Standards Association, consisting of 18 members, 16 ballots have been received, the vote in this case being affirmative to the extent of more than two thirds of those voting. The specifications in their revised form will also be offered by the sectional committee through the sponsor organizations to the American Standards Association for approval as American Standard.

This report has been submitted to letter ballot of the committee which consists of 28 members; 22 members returned their ballots, of whom 18 have voted affirmatively and 4 negatively.

Respectfully submitted on behalf of the committee,

R. P. MILLER,
Chairman.

FITZHUGH TAYLOR,
Secretary.

EDITORIAL NOTE

The Tentative Specifications for Fire Tests of Building Construction and Materials, as revised, were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1933. The specifications in their revised form appear in the 1933 Book of A.S.T.M. Standards, Part II, page 254.

REPORT OF COMMITTEE C-8

ON

REFRACTORIES

Committee C-8 on Refractories held one meeting during the year, in Pittsburgh, Pa., on February 13, 1933, in conjunction with the annual meeting of the American Ceramic Society.

It is believed that the most outstanding accomplishment of the committee during the past year was the sponsoring of the Refractories Manual. This manual contained the complete set of standard specifications and methods of test for refractory materials issued by the A.S.T.M. as developed by Committee C-8, together with Manual for Interpretation of Refractory Test Data. This Refractories Manual has been given extensive publicity and wide distribution and has been favorably received by those industries concerned with the production and use of refractories.

RECOMMENDATIONS AFFECTING STANDARDS

The recommendations of the committee regarding standards and tentative standards under its jurisdiction are summarized below, together with the analysis of the letter ballot on each item.

I. Proposed Tentative Standard:

Proposed Tentative Methods of Testing High-Temperature Heat Insulation.—In view of the general interest being shown in insulating refractories and the increasing use of such products in various types of industrial furnaces, it was considered advisable to establish test methods for determining the values of the essential properties of such high-temperature insulating materials. The Section on Heat Transmission (R. H. Heilman, chairman) has worked for several years on various methods of testing these products and at the last meeting, this committee presented proposed tentative methods for determining the compressive strength, flexural strength, and shrinkage of high-temperature heat insulating materials. The committee accordingly recommends that the proposed Tentative Methods of Testing High-Temperature Heat Insulation (Compression, Flexure, Shrinkage), appended hereto,[1] be accepted for publication as tentative.

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[1] See p. 684.—ED.

II. Proposed Revisions of Standards:

Standard Method of Test for Porosity and Permanent Volume Changes in Refractory Materials (*C 20 - 20*).[1]—The formula for calculating the apparent porosity has inadvertently been left out of this standard method. The committee is accordingly recommending for immediate adoption the inclusion of the following formula in Section 5 as a new Paragraph (*m*). The committee accordingly asks for the necessary nine-tenths vote at the annual meeting in order that this revision may be submitted to letter ballot of the Society for immediate adoption.

(*m*) *Apparent Porosity.*—The apparent porosity, *P*, shall be calculated by subtracting the dry weight from the wet weight and dividing by the volume of the test piece, and multiplying by 100 as follows:

$$P = \frac{W - D}{W - S} \times 100$$

Standard Method of Test for Softening Point of Fire-Clay Brick (*C 24 - 31*).[2]—This standard method requires that the test cone be mounted with the base embedded approximately 1 mm. (0.04 in.) in the plaque. It has been found that such shallow embedding is impracticable and the committee accordingly recommends that the following change in Section 4 be made immediately in the standard method. The committee accordingly asks for the necessary nine-tenths vote at the annual meeting in order that this revision may be submitted to letter ballot of the Society for immediate adoption.

Section 4.—Change the second sentence to read as follows by the addition of the italicized figures and the omission of those in brackets:

They shall be mounted with the base embedded approximately [1 mm. (0.04 in.)] *3 mm.* (*0.12 in.*) in the plaque and the face of one side inclined at an angle of 82 deg. with the horizontal.

Standard Method of Test for Refractory Materials Under Load at High Temperatures (*C 16 - 20*).[3]—In Section 2 (*d*) of this method option is given of using some form of optical pyrometer. The committee feels that for the sake of accuracy a closed end tube must be used in conjunction with the optical pyrometer and recommends for publication as a tentative revision the following change in this section:

Section 2 (*d*).—Add the following as a second paragraph of the present Paragraph (*d*):

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 207.

[2] 1931 Supplement to Book of A.S.T.M. Standards, p. 69.

[3] 1930 Book of A.S.T.M. Standards, Part II, p. 202.

If the optical pyrometer is used, observations shall be made by sighting into a refractory tube having a closed end in the same relative position to the test specimen as that specified for the thermocouple.

In several of the standards covering refractories prepared by Committee C-8 the term "softening point" still appears, whereas this property of fire clay, fire brick and silica cement is now known as "pyrometric cone equivalent." In 1931 it was tentatively proposed to change the title of the Standard Method of Test for Softening Point of Fire-Clay Brick (C 24 - 31) to read "Standard Method of Test for Determining the Pyrometric Cone Equivalent of Fire Clay and Fire Brick,"[1] but the term "softening point" was not changed in the various standards under the jurisdiction of Committee C-8. The committee therefore recommends that the term "softening point" in all of the C-8 specifications, methods of test and definitions be tentatively changed to "pyrometric cone equivalent." This applies to the following standards:

Standard Specifications for Clay Fire Brick for Malleable Furnaces with Removable Bungs and for Annealing Ovens (C 63 - 28);[2]

Standard Specifications for Clay Fire Brick for Stationary Boiler Service (C 64 - 28);[2]

Standard Specifications for Clay Fire Brick for Marine Boiler Service (C 65 - 28);[2]

Standard Method of Test for Softening Point of Fire-Clay Brick (C 24 - 31);[3]

Standard Definitions for Clay Refractories (C 27 - 28).[2]

In several of the standards covering refractories prepared by Committee C-8, the term "Orton cones" is used. In view of the fact that the original cones were developed by Mr. Hermann Seger, and that Mr. Edward Orton, Jr., based his cones on the Seger series and that he manufactured them in a company known as Standard Pyrometric Cone Co., it is felt by the Editorial Subcommittee that less confusion would occur if instead of using the term "Orton cones" the term "Standard Pyrometric Cones" were used. The committee therefore recommends that the term "Orton cones" be changed tentatively to "Standard Pyrometric Cones" in all C-8 specifications, methods of test and definitions where it appears.

III. Proposed Revision of Tentative Standard:

Tentative Method of Control Test for Resistance of Fire-Clay Brick to Thermal Spalling Action (C 38 - 31 T).[4]—In this method there are a number of variables which undoubtedly affect the results obtained in the test. One of these is the water trough used for immersing the heated brick. The committee believes that the trough should be standardized and recommends that the illustration shown in the accompanying Fig. 1 be incorporated in the method and suitable reference to it be made in Section 3 of the method which describes the spalling test procedure.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p., 998 (1932); also 1932 Book of A.S.T.M. Tentative Standards, p. 1142.

[2] 1930 Book of A.S.T.M. Standards, Part II, pp. 185, 191, 198, 224.

[3] 1931 Supplement to Book of A.S.T.M. Standards,p. 69.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 777 (1931); also 1932 Book of A.S.T.M. Tentative Standards, p. 410.

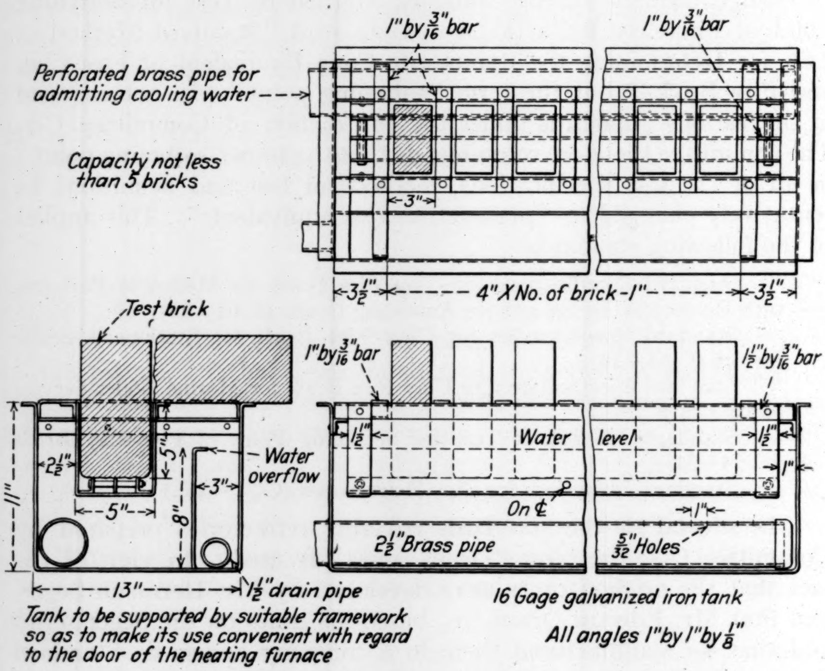
1" by 3/16" bar
1" by 3/16" bar
Perforated brass pipe for admitting cooling water
Capacity not less than 5 bricks
3"
3½"
4" X No. of brick -1"
3½"
Test brick
1" by 3/16" bar
1½" by 3/16" bar
11"
2½"
5"
Water overflow
5"
3"
8"
Water level
1½"
1½"
1"
On ℄
1"
2½" Brass pipe
5/32" Holes
13"
1½" drain pipe
16 Gage galvanized iron tank
Tank to be supported by suitable framework so as to make its use convenient with regard to the door of the heating furnace
All angles 1" by 1" by ⅛"

FIG. 1.—Proposed Apparatus for Cooling Brick in Spalling Test.

IV. Advancement of Tentative Revisions of Standards to Standard:

In the 1932 annual report the committee reported its approval of the advancement to standard of the tentative revisions,[1] proposed in 1931, in Section 5 of the Standard Method of Test for Porosity and Permanent Volume Changes in Refractory Materials (C 20 – 20) and in Section 2 of the Standard Method of Test for Softening Point of Fire-Clay Brick (C 24 – 31). At the 1932 annual meeting, these recommendations were referred to the Executive Committee with power and the advancement to standard of these tentative revisions was subsequently deferred until 1933. The committee accordingly asks that these proposed revisions in the two standard methods be approved at this annual meeting for submission to letter ballot of the Society for adoption.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, pp. 353, 997, 998 (1932); also 1932 Book of A.S.T.M. Tentative Standards, p. 1141, 1142.

The recommendations appearing in this report have been submitted to letter ballot of the committee, which consists of 35 members, with the following results:

Items	Affirmative	Negative	Not Voting
I. PROPOSED TENTATIVE STANDARD			
Methods of Testing High-Temperature Heat Insulation	28	1	1
II. PROPOSED REVISION OF STANDARDS			
Test for Porosity and Permanent Volume Changes in Refractory Materials (C 20 - 20), immediate adoption	30	0	0
Test for Softening Point of Fire-Clay Brick (C 24 - 31), immediate adoption	29	0	1
Method of Test for Refractory Materials Under Load at High Temperatures (C 16 - 20)[a]	25	3	2
Tentative Revisions of C-8 Standards:			
Changing of term "Softening Point" to read "Pyrometric Cone Equivalent"	30	0	0
Changing of term "Orton Cones" to read "Standard Pyrometric Cones"	28	1	1
III. REVISION OF TENTATIVE STANDARD			
Control Test for Resistance of Fire-Clay Brick to Thermal Spalling Action (C 38 - 31 T)	27	1	2
IV. ADVANCEMENT OF TENTATIVE REVISION OF STANDARDS TO STANDARD			
Standard Method of Test for Porosity and Permanent Volume Changes in Refractory Materials (C 20 - 20)	31	0	0
Standard Method of Test for Softening Point of Fire-Clay Brick (C 24 - 31)	31	0	0

[a] The classified vote on the proposed revision of Standard Method C 16 was as follows: Affirmative, 11 producers, 6 consumers, 8 general interests; negative, 1 producer, 2 general interests; not voting: 1 producer and 1 general interests.

ACTIVITIES OF SUBCOMMITTEES

Subcommittee II on Research (S. M. Phelps, chairman).—This subcommittee is developing a warpage test meter.

Standard Samples of Refractory Materials.—The final certificate for the standard sample of silica brick and the provisional certificate for the standard sample of magnesite brick have been issued by the U. S. Bureau of Standards. The first preliminary results on the standard sample of chrome ore have all been turned in. A method of analysis for magnesite refractories which is highly accurate and at the same time adaptable for routine work has been developed.

Subcommittee IV on Industrial Survey (L. C. Hewitt, chairman).—This subcommittee has been making a study of refractories for the non-ferrous industry.

Investigation of the P.C.E. Test.—The Section on Temperature has been conducting a study on the rate of heating in the P.C.E. test. Preliminary results seem to conflict with the generally accepted idea that rate of heating is very important. Some study has also been made on the variations in size of pyrometric cones.

The Section on Microstructure has been working on the 10 per cent level of the multiple component system involved in the interaction of slags and refractories in boiler furnaces and the Section on Slagging is attempting to correlate slag test data with performance in service.

This report has been submitted to letter ballot of the committee, which consists of 35 members; 28 members returned their ballots, of whom 23 have voted affirmatively and 3 negatively.

Respectfully submitted on behalf of the committee,

G. A. BOLE,
Chairman.

C. E. BALES,
Secretary.

EDITORIAL NOTE

The proposed Tentative Methods of Testing High-Temperature Heat Insulation were accepted for publication as tentative and appear on page 684.

Revisions proposed for immediate adoption in the Standard Method of Test for Porosity and Permanent Volume Changes in Refractory Materials and for Softening Point of Fire-Clay Brick were approved at the annual meeting by a unanimous vote and were subsequently adopted by letter ballot of the Society on September 1, 1933. The methods in their revised form appear in the 1933 Book of A.S.T.M. Standards, Part II, pages 176 and 184, respectively.

The proposed revision of the Standard Method of Test for Refractory Materials Under Load at High Temperatures was accepted for publication as tentative and appears on page 1032. The recommendation that the term "softening point" be changed to read "pyrometric cone equivalent" and that the term "Orton cones" be changed to read "Standard Pyrometric Cones" in the standards under the jurisdiction of the committee was accepted for publication as a tentative revision and appear on pages 1032 and 1034.

The proposed revision of the Tentative Method of Control Test for Resistance of Fire-Clay Brick to Thermal Spalling Action was accepted. The method in its revised form appears on page 689.

The tentative revisions of the Standard Method of Test for Porosity and Permanent Volume Changes in Refractory Materials and for Softening Point of Fire-Clay Brick were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1933. The methods in their revised form appear in the 1933 Book of A.S.T.M. Standards, Part II, pages 176 and 184, respectively.

REPORT OF COMMITTEE C-9
ON
CONCRETE AND CONCRETE AGGREGATES

Committee C-9 on Concrete and Concrete Aggregates held two meetings during the year, one on November 28, 1932, at Washington, D. C., and the other in New York City, on March 10, 1933. Both meetings were well attended considering the low ebb of economic conditions.

A number of new members have been added to the committee during the year, and the organization of a new Subcommittee XI on Evaluation of Data was authorized. This subcommittee will consider statistical methods for the presentation and analysis of data and the application of the laws of probability as related to tests of concrete and concrete aggregates. Special attention will be given to the problem of the number of specimens or samples needed for accuracy in the results of the various tests.

The work of the committee has crystallized in the preparation of two new proposed tentative methods of test and one new tentative specification; also recommendations for the advancement to standard of four tentative revisions of existing standards; and the preparation of a Report on the Significance of Tests of Concrete and Concrete Aggregates.

The following two papers presented by subcommittees have been submitted for publication as appendices to this report:

> "The Action of Water on Concrete" by B. Kellam.
>
> "A Study of the Analysis of Fresh Concrete with the Dunagan Buoyancy Apparatus" by H. R. Nettles and J. M. Holme.

The committee believes that the Report on Significance of Tests of Concrete and Concrete Aggregates, referred to above, represents an outstanding contribution. The purpose of this compilation is to present an effective summation of the significance, limitations, and applicability of the more widely used tests for concrete and concrete aggregates; including discussion of their importance, whether they adequately present a true picture of what can be expected of the material, and other pertinent factors. The compilation of the report is under the immediate direction of the following committee: R. W. Crum, chairman, A. T. Goldbeck and F. H. Jackson. It has received the review of the entire membership of the committee and has been approved by it. A summary of the report appears in Appendix I.

RECOMMENDATIONS AFFECTING STANDARDS

I. Proposed Tentative Standards.—The committee submits for publication as tentative the following specification and two methods of test as appended hereto:

Proposed Tentative Specifications for Ready Mixed Concrete.[1]—These specifications have been prepared by Subcommittee XVIII on Ready Mixed Concrete (R. B. Young, chairman) at the request of the Ready Mixed Concrete Association. Ready mixed concrete has been steadily growing in importance and it was apparent to the committee that a standard specification would be of assistance to users and producers alike, as the conditions of its production and marketing differ from those of concrete made on the job.

Proposed Tentative Method of Test for Absorption by Aggregates for Concrete (Laboratory Determinations)[2]; and

Proposed Tentative Method of Field Test for Absorption of Mixing Water by Aggregates for Concrete.[3]—Subcommittee IX on Specifications and Methods of Tests of Aggregates (H. F. Clemmer, chairman) has developed both of these absorption tests for aggregates. The principal need for standardizing these two methods arises from the fact that determinations of absorption have become of great importance in connection with arranging proportions for concrete mixtures and with measurements of the ingredients in the field.

II. Proposed Revision of Standards.—The committee recommends that the tentative revisions, proposed in 1932,[4] of the following methods be submitted to letter ballot of the Society for advancement to standard:

Standard Method of Making and Storing Compression Test Specimens of Concrete in the Field (C 31 – 31);[5]

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[1] See p. 703.—ED.

[2] See p. 711.—ED.

[3] See p. 713.—ED.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, pp. 359 and 1000 (1932); also 1932 Book of A.S.T.M. Tentative Standards, p. 1144.

[5] 1931 Supplement to Book of A.S.T.M. Standards, p. 58.

Standard Methods of Making Compression Tests of Concrete (C 39 - 27);[1]

Standard Method of Test for Organic Impurities in Sands for Concrete (C 40 - 27);[1]

Standard Method of Test for Sieve Analysis of Aggregates for Concrete (C 41 - 24).[1]

The recommendations appearing in this report have been submitted to letter ballot of the committee, which consists of 60 members, with the following results:

Items	Affirmative	Negative	Not Voting
I. PROPOSED TENTATIVE STANDARDS			
Tentative Specifications for Ready Mixed Concrete	41	1	1
Tentative Method of Test for Absorption by Aggregates for Concrete (Laboratory Determinations)	38	2	3
Tentative Method of Field Tests for Absorption of Mixing Water by Aggregates for Concrete	39	1	3
II. ADVANCEMENT OF TENTATIVE REVISION OF STANDARDS TO STANDARD			
Method of Making and Storing Compression Test Specimens of Concrete in the Field (C 31 - 31)	43	0	0
Methods of Making Compression Tests of Concrete (C 39 - 27)	43	0	0
Method of Test for Organic Impurities in Sands for Concrete (C 40 - 27)	38	3	2
Method of Test for Sieve Analysis of Aggregates for Concrete (C 41 - 24)	42	0	1

This report has been submitted to letter ballot of the committee, which consists of 60 members; 43 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

R. W. CRUM,
Chairman.

R. R. LITEHISER,
Secretary.

EDITORIAL NOTE

The proposed Tentative Specifications for Ready Mixed Concrete, proposed Tentative Method of Test for Absorption by Aggregates (Laboratory Determinations) and Method of Field Tests for Absorption of Mixing Water by Aggregates were accepted for publication as tentative and appear on pages 703, 711 and 713, respectively.

The tentative revisions of the Standard Method of Making and Storing Compression Test Specimens of Concrete in the Field, of Making Compression Tests of Concrete, of Test for Organic Impurities in Sands for Concrete and of Test for Sieve Analysis of Aggregates for Concrete were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1933. The methods in their revised form appear in the 1933 Book of A.S.T.M. Standards, Part II, pages 225 to 241, inclusive.

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[1] 1930 Book of A.S.T.M. Standards, Part II, pp. 143, 154, 155.

APPENDIX I

SUMMARY OF REPORT ON SIGNIFICANCE OF TESTS OF CONCRETE AND CONCRETE AGGREGATES

The Report on Significance of Tests of Concrete and Concrete Aggregates, assembled under the auspices of Committee C-9 during the past year, covers both the Significance of Tests of Concrete and the Significance of Tests for Concrete Aggregates. The various sections, together with the individual responsible for the preparation of each section, is given below:

Significance of Tests for Characteristics of Concrete:

Compressive Strength. Inge Lyse.
Tensile and Transverse Strength. A. T. Goldbeck.
Shearing Strength. A. T. Goldbeck.
Elastic Properties. F. E. Richart.
Durability Tests. C. H. Scholer.
Workability. J. C. Pearson.
Volume Changes. R. E. Davis and J. W. Kelly.
Uniformity. R. L. Bertin.
Routine Analysis of Cement Content of Hardened Portland Cement Concrete. H. F. Kriege.

Significance of Tests for Characteristics of Aggregates:

Gradation, Specific Gravity, Unit Weight and Voids of Concrete. Fred Hubbard.
Deleterious Substances. F. C. Lang.
Soundness of Aggregates. Stanton Walker.
Free Moisture and Absorption. Bert Myers.
Abrasion Tests of Aggregates. H. F. Clemmer.
Mortar Strength Tests of Fine Aggregates. F. H. Jackson.

In addition, a section on "The Numbers of Specimens or Tests Required for Reasonable Accuracy of the Average" was prepared by Mr. R. W. Crum.

There is an introduction to the report prepared by Prof. A. N. Talbot calling attention to the three types of tests, namely, experience tests, informational tests and investigational tests which have important functions but require in the interpretation of their significance a full understanding with a good degree of judgment of their meaning and their limitations.

The various sections were assembled by a committee consisting of R. W. Crum, chairman, A. T. Goldbeck, and F. H. Jackson. The report, however, has been reviewed by the entire membership of the committee and has been approved by it. This report is being issued as a separate publication.

APPENDIX II

THE ACTION OF WATER ON CONCRETE

By B. Kellam[1]

There is increasing evidence pointing to the conclusion that the compounds formed by the setting and hardening of cement are decomposed by water. Practically, this means that concrete such as dams and other hydraulic works may be deleteriously affected by the solvent action of the water with which they are in contact, and this would be particularly serious if the concrete was porous or permeable so that the water would penetrate the interior.

From the researches so far made it would appear that the action of water on concrete is principally one of hydrolysis whereby the calcium compounds are split up with liberation of free lime, CaO, which is in turn converted into calcium hydroxide, $Ca(OH)_2$ by the addition of water.

Lerch and Bogue[2] found that when pure water was brought into contact with compounds existing in portland cement and the products of hydrolysis were intermittently removed, eventually all of the calcium hydroxide would be leached out and only hydrous silica, ferric oxide and alumina would remain. When the products of hydrolysis were not removed, action ceased after a definite concentration of $Ca(OH)_2$ was attained. In general, when the liquid became saturated with calcium hydroxide no hydrolysis would take place. None of the compounds gave up all of their available lime under such a condition.

When carbon dioxide is bubbled through pure water, it dissolves and the water becomes acid, that is, the pH value is lowered from 7.0 (neutrality). Such an acid water affects concrete in various ways.

Baylis[3] considered that the structural formation of cement mortar was of a fibrous nature, the voids in the surface of which served as passages for the diffusion of lime from the interior of the concrete to the surface. If the concrete was not submerged in water, the carbon dioxide in the air would combine with the surface lime set free by the setting cement precipitating calcium carbonate, and the voids would thus be reduced in size to the "stagnated" state, preventing diffusion of the lime to the surface. If the concrete was exposed to water corrosive to calcium carbonate, the latter would be dissolved away as soon as formed, and the water in the pores now unsaturated with respect to calcium hydroxide would dissolve more of the latter. Thus there would be a continuous travel of $Ca(OH)_2$ from the interior to the surface resulting in a loss of lime from within the concrete.

Additional work on the action of carbonic acid waters was carried out by Tremper.[4] Artificially acidulated water was made to a definite pH value and permitted to flow over and around concrete specimens for a lengthy period of time. The loss in compressive strength was noted and related to the loss in lime as found by the decrease in weight of the specimens. The conclusions which are of most interest in this study are as follows:

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[1] Assistant Chemist, Hydro-Electric Power Commission of Ontario, Toronto, Ont., Canada.

[2] W. Lerch and R. H. Bogue, *Journal of Physical Chemistry*, Vol. 31, p. 1627 (1927).

[3] J. R. Baylis, *Transactions*, Am. Soc. Civil Engrs., Vol. 90, p. 791 (1927).

[4] B. Tremper, *Journal*, Am. Concrete Inst., Vol. 3, p. 1 (1931).

1. The solubility of lime increased with the acidity of the water.

While this refers to acidity due to carbonic acid, it is naturally true for all acids.

2. If the pH value of the water is above 7.0, the attack, in general, is too mild to be of practical consequence.

Taken as it stands, this statement is hardly correct and will be discussed later in this paper.

3. The character of the aggregate probably has little effect on resistance. If there is a difference between aggregates it cannot be connected with results of usual inspection or tests.

This is probably true for the conditions of test where water flowed over and around the concrete, but is this true where water percolates *through* the concrete?

4. Concrete of high quality is markedly more resistant than poor concrete.

Our experience brings us to the same conclusion. The experimental evidence, however, is restricted to surface action and it was found that rich and poor mixes were equally affected by aggressive water. This also agrees with our findings, cases having been known where surfaces in contact with corrosive waters etched to the same extent, although of different mixes.

5. Loss of lime causes a decrease in the strength of concrete. When about 50 per cent of the original lime has been removed from average concrete complete loss of strength and coherence results.

Experimental work had shown that the strength of any stage was determined by the ratio of original water content to the lime content at that stage. Curves were drawn to show the loss in strength as the lime content was decreased by the acid water. This was carried on to a 27 per cent lime loss and a consequent reduction in the strength ratio to about 60 per cent. To complete the curve to the zero strength point, analysis was made of a piece of concrete taken from a badly corroded structure and it was calculated that 57 per cent of the lime had been removed by solution. The strength was considered zero and 50 per cent loss in lime was therefore chosen as the amount to be removed from the concrete to cause the latter to fail completely. It would be interesting, in connection with the above, to know the complete analysis of the corroded material, especially with respect to the SO_3 content. From the description of the type of corrosion it appears strikingly similar to that caused by the action of sulfate waters. Without knowledge of the SO_3 content of the concrete it would be erroneous, it is thought, to make the assumption that corrosion was caused by percolating normal water.

6. Aside from a severe attack of about $\frac{1}{16}$ in. at the surface, loss in lime with the resultant loss in strength is uniform throughout the body of the concrete for a depth of at least 15 in. from the surface.

The conclusion that there was a transfer of lime from the interior of the concrete to the surface was based on experiments wherein groups of specimens in layers were exposed to acid waters in such a manner that only the top of the upper piece was exposed to the water; the sides were caulked with tin foil and melted paraffin poured around the foil. At the end of 22 months each specimen in the group was weighed and it was found that each had experienced a decrease in weight down to the bottom one, at a depth of 15 in.

From the data given concerning the mix used, it was calculated that the loss in weight of the entire specimen was about 0.7 per cent (the difference between specimens is too small to be of any significance). This decrease in weight is altogether too small to warrant the conclusion that lime had diffused from a depth of 15 in. to the surface. The experimental error due to handling the specimens, drying out, etc., could very easily be equal to this decrease.

There is, however, an additional point in connection with this experiment. The group of nine specimens of the 4.5 gal. per sack mix lost a total of 17.8 g. of lime, according to the tabulation. Water is the medium by which the lime in the concrete must be brought to the surface in solution. Assuming that the content of CO_2 for city water having the pH value of 6.0, such as that used, is 0.055 g. per l., which would be a reasonable figure, it would require 514 l. or 143 U. S. gal. of water to convert this lime to the carbonate, and then dissolve it out as the bicarbonate. In other words, 258 l. of water must have passed through the exposed surface of the top specimen to convert the lime lost to $CaCO_3$ and an additional 256 l. to dissolve out this $CaCO_3$ as the bicarbonate.

Any investigation of the action of water on concrete must consider the effect of the carbon dioxide which is present in most waters. Our present knowledge may be summed up briefly as follows:

The surface lime present in concrete is in the form of calcium carbonate. In pure water free from CO_2 the solubility of this compound is about 13 p.p.m. If carbon dioxide is introduced, the solubility of $CaCO_3$ is increased and the compound calcium bicarbonate is said to form. Free CO_2 is necessary to hold this excess of $CaCO_3$ in solution and the solubility is proportional to the free CO_2 content. Below the surface of the concrete, the lime is present as calcium hydroxide and the solubility in pure water is 1650 p.p.m. If a solution of $Ca(OH)_2$ is introduced to a liquid containing calcium bicarbonate (and therefore free CO_2), it is converted to the much less soluble calcium carbonate by combining with some of the free CO_2. The removal of the latter causes a proportional amount of CaCO which was held in solution by it to be thrown out of solution.

Any CO_2 present in the water in excess of the amount necessary to keep calcium carbonate in solution as the bicarbonate has been termed "aggressive" CO_2. This term was originated by J. Tillmanns[1] to designate this excess which alone has the power to attack (dissolve) calcium carbonate in the surface concrete. The CO_2 belonging to the calcium bicarbonate in solution was termed "bonded" CO_2. It was shown that there was a definite amount of bonded CO_2 for each content of calcium bicarbonate and a constant was calculated with the aid of which one could be determined from the other. This has been arranged in both tabular and graphic form.[2] Thus, with their use, having obtained the free and combined CO_2 content of a water, one can determine that portion of CO_2 which can affect attack on calcium carbonate and only this excess can dissolve calcium carbonate. The same remarks apply to the corresponding magnesium salts.

When a structure is partially immersed in water, the level of which varies, the action of acid water is manifest only when the free CO_2 is relatively high and the amount of $CaCO_3$ held in solution is low. Such a water may be termed "lime hungry" for, as indicated above, the aggressive CO_2 will be high and the water will tend to dissolve the calcium carbonate layer in the surface of the concrete. In stagnant water this will continue until all the aggressive CO_2 has been converted to bonded CO_2. Then the solvent action will cease. In moving water the latter has not the opportunity to become sated with lime and the solvent action goes apace with loss of surface calcium carbonate. The calcium hydroxide beneath is in turn converted to calcium carbonate which is precipitated in the surface voids and the re-solution goes on. Eventually the surface becomes etched to a depth where it becomes apparent to the eye, the aggregate being left projecting from the surface.

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[1] J. Tillmanns, "Die Chemische Untersuchung von Wasser und Abwässern," p. 84, 1915 Edition.

[2] Auerbach, *Gesundheits-Ingenieur*, Vol. 35, p. 869 (1912).

It will be seen from the above that the ideal water, that is, with least solvent action, would be one relatively high in calcium carbonate content and low in bicarbonate or free CO_2. Hence, the suggestion from Europe that the banks of a stream leading to a concrete structure be lined with limestone rock so that the water could take up calcium carbonate and reduce the aggressive CO_2 to zero.

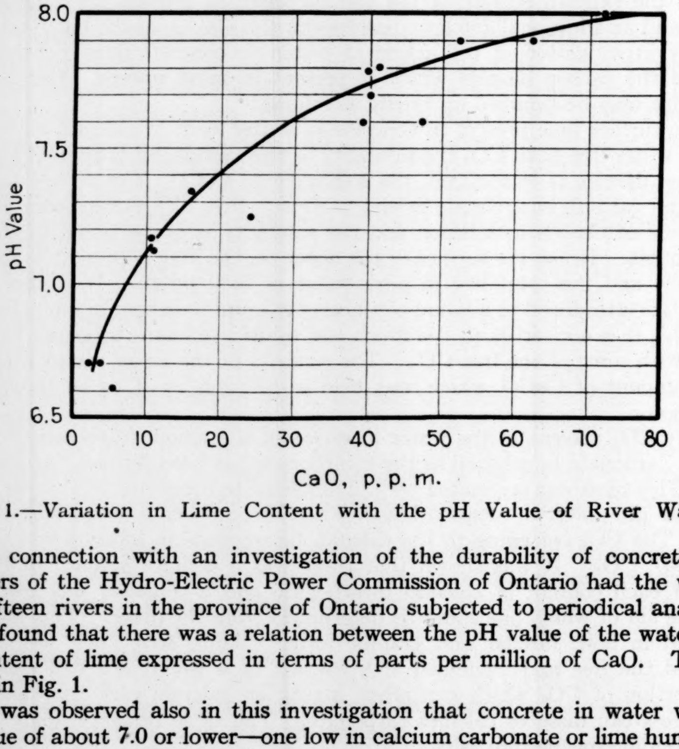

FIG. 1.—Variation in Lime Content with the pH Value of River Water.

In connection with an investigation of the durability of concrete, the engineers of the Hydro-Electric Power Commission of Ontario had the waters from fifteen rivers in the province of Ontario subjected to periodical analyses. It was found that there was a relation between the pH value of the water and the content of lime expressed in terms of parts per million of CaO. This is shown in Fig. 1.

It was observed also in this investigation that concrete in water with a pH value of about 7.0 or lower—one low in calcium carbonate or lime hungry—showed the phenomenon of surface etching to a far greater extent than those in waters with a higher pH value. In other words, the water tends to saturate itself with lime (as mentioned above) and will have a solvent action on the cementitious part of the concrete inversely proportional to the original lime content of the water.

It should not be assumed from the foregoing that a water whose pH value is higher than 7.0 has very little action on concrete. It will be recalled earlier in this paper that such a conclusion was reached by one investigator. This is an assumption made by many and is erroneous. Evaluation of the pH value cannot be used with safety as a criterion of the harmful action that a water may exert. It must be accompanied by a chemical analysis of the water.[1] Examples are known where the pH value was well above 7.0 and the water was very harmful because of the presence of considerable sulfates. A few of these personally experienced and some from the literature are given below:

pH VALUE	SO_3, P.P.M.
7.00	1623
7.50	1339
8.00	1078
8.00	2847
8.25	2026

That such waters would have a harmful action on concrete there will be no doubt. This shows the necessity for a complete chemical analysis of a water before any interpretation can be placed on the pH value.

While the different investigators are not in complete agreement, the combined evidence that they present would seem to justify the following general conclusions:

1. Water has a solvent action on the lime set free by the hydrolysis of cement in concrete.

2. With a continuous flow of water all the lime will eventually be removed.

3. The presence of carbon dioxide in the water increases the solvent action of the latter on calcium carbonate, in which form the lime is present at the surface.

4. The solvent action of a water is proportional to the amount of free CO_2 present in excess of that required to convert the calcium carbonate in the water to calcium bicarbonate, that is, proportional to the aggressive CO_2 present.

5. A complete chemical analysis of a water is necessary before any significance can be attached to the pH value.

6. If the SO_3 is less than 25 p. p. m. injury from this source will be mild and inconsequential. When the SO_3 is in the hundreds of p. p. m. it is a possible source of great harm and protection must be provided.

7. If the SO_3 is under 25 p. p. m., then and only then is the pH value of any significance in determining the solvent effect of a water. If the pH value is 7.0 or higher there will be practically no solvent action. If the pH value is lower than 7.0 the attack is greater as the pH value is lowered, that is as indicated in conclusion 4 above.

8. Where the aggressive CO_2 is present in quantity (pH value quite low), solvent action becomes manifest by etching of the surface concrete leaving the aggregate projecting.

It has been thought that the development of a method of diagnosing the sicknesses of a concrete before the latter has succumbed would be of great value to the concrete engineer. With the passage of time many changes take place within and without a structure, the results of which are sometimes visible to the eye and which doubtless have a definite significance in relation to the durability of such a structure. Reference is made here solely to concrete exposed to water pressure on one side. These changes seem to take place in a definite order from observations made. A typical case is as follows:

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[1] K. Biehl, *Zement*, Vol. 19, p. 269 (1930).

The first change is the appearance at intervals of patches of a soluble efflorescence. This finally ceases and only the edges of the patch carry the deposit. The boundary of the patch gradually lengthens, but the center remains clear of the soluble efflorescence. Then there is the appearance of deposits of calcium carbonate, covering at times quite an extensive area. Finally there is the appearance of brown, sometimes red, stains around the seepage surfaces and it has been common experience that at this stage the concrete has failed to the extent that repairs are necessary.

Because these changes are of a chemical nature, analysis of the affected portions may provide the means for diagnosis of the stage in the deterioration of concrete. But first the significance of these changes must be known. The following is a suggestion of what may be taking place:

The soluble efflorescence that appears on the surface of concrete consists almost entirely of sodium and potassium salts. Since these constitute the most soluble salts in concrete, the water in the capillaries soon becomes saturated with them. When conditions are correct, that is, during a dry period, the water evaporates and they deposit in the capillaries and on the surface, the area of which is dependent on the area of porous concrete behind it. The movement of water contained in this porous area will tend toward the surface where evaporation is taking place at the greatest rate[1] and the deposit of salt will continue as long as there is water to carry it to the surface. Should a wet period occur, the salts on the surface dissolve immediately in the first drops of water, and part of the solution thus formed is sucked back through the capillaries into the porous area. (Such a phenomenon can be observed when a patch of efflorescence is given a light spraying with water.) The salts now consist of carbonates and contact with the calcium hydroxide below the surface would result in the conversion of the latter to calcium carbonate and the sodium and potassium salts to their respective hydroxides.

Following another dry period the hydroxides are brought to the surface and converted to the carbonates by the CO_2 of the air. Successive wet periods, sometimes with the aid of seepage water, tend to remove these soluble salts and they are eventually leached out.

The presence of these soluble salts of sodium and potassium is generally overlooked by most investigators and even less attention is given to the possibility that they may have any influence towards the disintegration of concrete. This is probably because they are present to such a small extent in the cement and much less in the finished concrete. Yet the presence of the salts of sodium and potassium may provide the "thin edge of the wedge" in several ways:

1. The concentration and crystallization of their salts in the surface capillaries and the conversion of calcium hydroxide to the carbonate would tend to establish numerous small paths from the surface to that below. This enlarges the scope of frost action, giving a better grip to the latter, and helping to shorten the path through which water must penetrate from the opposite side.

2. The deterioration of concrete structures at construction joints is a well known phenomenon. While undoubtedly it is usually brought about by faulty placing methods and the use of excessively wet mixtures, it is also probable that it is due in part to the concentration of soluble sulfates of sodium and

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[1] A. P. Laurie and J. Milne, *Proceedings*, Royal Soc. Edinburgh, Vol. 47, p. 52 (1926).

potassium at these points, some of which are entrapped near the surface of the setting concrete. The segregation of these soluble sulfates near the surface of horizontal joints can affect considerable injury: (*a*) when they are leached out by washing and rain, leaving a porous surface to the action of frost or seepage water; (*b*) when the sulfates leached out accumulate in pockets and form calcium sulfoaluminate with accompanying swelling and spalling. Of the two the first, (*a*), is the more common.

Proof of the presence of high concentrations of sulfates is shown by the following analysis made from materials taken during construction of a large dam. The laitance water along with some of the laitance carried up was analyzed, together with the cement and mix water used:

	MIX WATER	LAITANCE WATER
Carbonate CO_2, p.p.m.	20.0	50.0
Bicarbonate CO_2, p.p.m.	0	......
Alkalinity as (OH), p.p.m.	....	1690.0
Chlorine, p.p.m	1.5	25.0
Silica (SiO_2), p.p.m.	4.0	3.5
$Fe_2O_3 + Al_2O_3$, p.p.m.	Trace	......
Cr_2O_3, p.p.m.	0	26.7
CaO, p.p.m.	8.5	858.0
MgO, p.p.m.	3.0	0
SO_3, p.p.m.	3.7	3305.0
Na_2O, p.p.m.	2.0	1580.0
K_2O, p.p.m.	2.6	4057.0
Total by analysis	25.3	9855.0

	CEMENT	LAITANCE
Loss on ignition, per cent	1.02	23.50
SiO_2, per cent	20.63	16.86
$Fe_2O_3 + Al_2O_3$, per cent	9.73	6.40
CaO, per cent	64.10	43.46
MgO, per cent	2.02	2.16
SO_3, per cent	1.60	7.80
Na_2O, per cent	0.22	0
K_2O, per cent	0.45	0
Total	99.77	100.18

These will give an idea of the high concentrations of soluble sulfates in the water which comes to the surface of freshly placed concrete.

The next change in the concrete, the most familiar one, commences with the appearance of a deposit of calcium carbonate which builds up over an extensive area and in stalactites over the surface. This is an indication that water has found a passage from the pressure side to the surface, and is carrying with it the calcium hydroxide which it has dissolved on its way through. The CO_2 converts the lime to the carbonate which precipitates on the surface.

Evaporation from an exposed surface may also cause an internal movement of water in concrete with its consequent solution of lime and weakening of the material. A familiar example of this occurs above the water line of partially submerged concrete when the latter is porous. It has also been observed in slabs or walls having water on one side. But whatever the cause, whether pressure, evaporation or absorption, the effect is the same—there is a gradual solution of the cementitious material of the concrete wherever there is an internal movement of moisture.

The final stage is the appearance of brown (and red) stains on the seepage surfaces and these may often be seen coloring the glaze of calcium carbonate that has deposited on the concrete. Just what is the nature of this compound is not known,—it may be a simple calcium silicate or ferrite. The interior close to defective concrete also bears this biscuit-brown color. It is thought that the appearance of this coloration is connected with the lowering of the pH value inside the concrete due to the leaching of the lime by seepage water. The high pH value normally existing within the moist concrete probably prevents this reaction taking place. When sufficient lime is leached out and the pH value drops, this protection is removed and the new colored compound results.

Field observations indicate that generally when this coloration appears on the surface, the concrete in the vicinity is in a weakened condition, and is close to actual disintegration and will very soon be in need of repairs.

The presence of reinforcement tends to complicate matters and being so common, any discoloration is generally assumed to be rust stains. But when they are not too deeply embedded, rusting reinforcements produce cracks in the concrete due to the nearly three-fold increase in volume when iron rusts, and this serves as a means for distinguishing the two. A further complication is introduced because the high pH value of the seepage water saturated with calcium hydroxide protects iron from rusting and the latter also begins when the pH value becomes low. By this time, due to the opening of fissures in the weakened concrete, air and CO_2 gain entry and cause the reinforcements to rust. Thus the one change—drop in pH value—may produce discoloration from two different sources. It is generally difficult to get a sample of concrete from within the affected area since it is usually some distance from the surface. A chemical analysis would show up the deficiency in lime when compared with a similar sample from an unaffected area.

Experimental work is being planned and under way in an attempt to reproduce the leaching effect of water carried over a lengthy period of time, and to see whether chemical analyses at various stages can be used as a means for diagnosing the particular stage in the deterioration of concrete.

APPENDIX III

A STUDY OF THE ANALYSIS OF FRESH CONCRETE WITH THE DUNAGAN BUOYANCY APPARATUS[1]

BY H. R. NETTLES[2] AND J. M. HOLME[2]

Introduction and Summary:

This paper presents the results of an investigation carried out in the Fritz Engineering Laboratory of Lehigh University to determine the efficiency of the Dunagan buoyancy apparatus for the analysis of fresh concrete. The tests were begun in November, 1930, and were completed in March, 1932. While the major part dealt with the analysis of concrete mixes, considerable attention was given to the properties of the cement and aggregates used in these mixes.

In brief, the results of the cement and aggregate tests showed that:

1. The specific gravity determination of cement was affected by the length of time of immersion. Samples of cement which were immersed and stirred only upon introduction into the weighing bucket showed a 2 per cent increase in specific gravity. Samples of cement which were stirred frequently during the immersion showed an 8 per cent decrease in specific gravity.

2. The specific gravity determination of fine aggregates was also affected by the length of time of immersion. Samples of fine aggregate which were stirred frequently during immersion showed an increase, while samples which were allowed to remain undisturbed were found to show a decrease in specific gravity.

3. The specific gravity determination of coarse aggregates increased with the length of time of immersion, and the resulting values were unaffected by stirring.

4. The large variations in grading of any one cement or aggregate required a large number of tests in order to determine the correction factors to be used for the No. 100 sieve.

The analysis of the concrete showed that:

1. Under field conditions the analyses showed variations in determined water content of 1.0 gal. per sack of cement.

2. Under laboratory conditions the analyses showed a variation in determined water content as great as 1.1 gal. per sack of cement.

3. With correction factors for the fineness of the materials eliminated, the determined water content showed a maximum variation of 0.45 gal. per sack of cement from that for which the mix was designed.

4. With the error in sampling eliminated, a variation of 0.3 gal. per sack of cement was found between individual samples.

5. When both fineness and sampling had been eliminated the variation in water content was as great as 0.35 gal. per sack of cement.

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[1] W. M. Dunagan, "A Study of the Analysis of Fresh Concrete," *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 362 (1931).

[2] Formerly Instructors in Civil Engineering, Lehigh University, Bethlehem, Pa.

6. A study of significant figures showed that slide-rule computations were sufficiently accurate for the analysis of the mix.

Cement:

Studies of cement were made to determine two factors: (1) variation in specific gravity with length of time of immersion, and (2) variation in grading. In the first study three different test procedures were used.

In the first procedure a 1000-g. sample of cement was carefully poured into the weighing bucket which was partly filled with water. After thorough stirring, the bucket was filled with water and allowed to stand for three minutes before weighing. The bucket then remained undisturbed until the test was completed. The data are presented in Fig. 1 and indicate that the specific gravity of the cement increased considerably during the first hour of immersion. Thereafter the increase was relatively slow.

The second procedure was essentially the same as the first except that the cement was stirred thoroughly and then allowed to settle for three minutes prior to each weighing. Bubbles of air or gas were observed to escape during the stirring. The data from the second series of tests are also plotted in Fig. 1. The specific gravity of the cement decreased as the length of time of immersion increased. This is contrary to the results found with the first procedure.

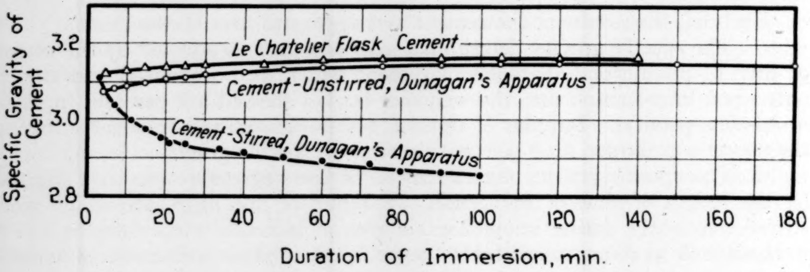

FIG. 1.—Variation in Specific Gravity of Cement with Duration of Immersion.

The curves marked "stirred" and "unstirred" in Fig. 1 indicate that it is possible to have a variation as great as 10 per cent in the specific gravity of the cement. Consequently, the observed cement content might vary by 10 per cent and the water content by a corresponding amount.

For the third procedure, tests were made using Le Chatelier flasks. The A.S.T.M. standard methods[1] were followed except that water instead of kerosine was used as the liquid. The flasks were not disturbed after the initial reading. Several attempts were made to find the effect of released gases or air, but it was impossible to free visible beads or globules. The data which are plotted in Fig. 1 show a close agreement between the results obtained on unstirred cement by using the Le Chatelier flask and the Dunagan apparatus.

The authors offer as an explanation of the results showing a decrease in specific gravity, the instability of the cement particles in water. When the cement was placed in the water and left unstirred, bubbles were seen to escape only upon its introduction. When stirred, a considerable quantity of air or gas was seen to escape and the gravity was found to decrease. From this it is concluded that stirring accelerates the reaction between cement and water with the evolution of a gas and a resulting loss in weight and volume.

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[1] Standard Methods of Test for Apparent Specific Gravity of Sand, Stone and Slag Screenings, and other Fine Non-Bituminous Highway Materials (A.S.T.M. Designation: D 55 - 25), see 1933 Book of A.S.T.M. Standards, Part II, p. 996.

The percentages of cement retained on the No. 100 sieve were determined both by dry and wet sieving. Approximately 0.2 per cent more was retained by dry than by wet sieving.

Fine Aggregate:

The variation in the specific gravity of sand with the length of time of immersion was determined by two different methods, as follows:

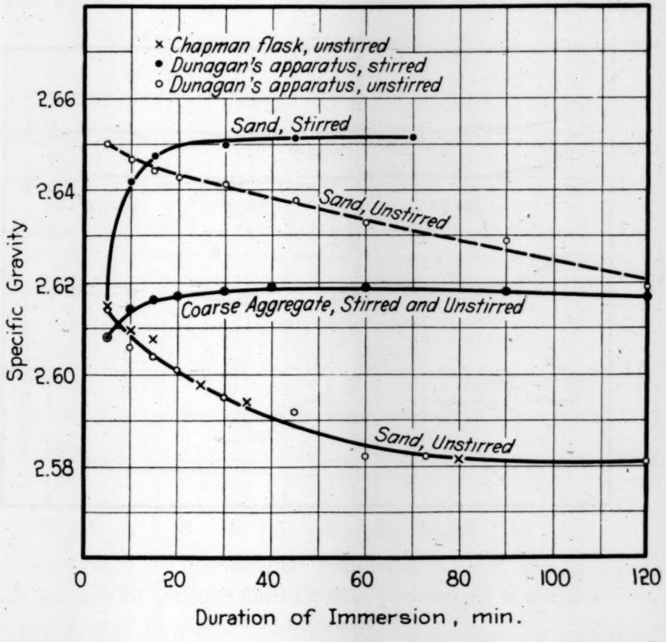

FIG. 2.—Variation in Specific Gravity of Sand and Gravel with Duration of Immersion.

In the first method a 1000-g. sample of dried sand was placed in the weighing bucket, stirred to free entrapped air and weighed immersed. Without further disturbance, the sample was weighed at regular intervals during a 2-hr. period. The weights instead of increasing, actually decreased up to 1½ hr., showing a 1.2 per cent decrease in the specific gravity (Fig. 2). This would indicate that the volume of the sand and the entrapped air increased during the immersion. The test was repeated on sand from a different source (Bogert sand, see Fig. 2) and the results agreed quite well. In order to check these results, a test was made using the Chapman flask.[1] The dried sand was carefully introduced into the flask which contained 200 cc. of water. Except for a thorough shaking immediately after the sample had been introduced, the flask was not disturbed. The results were found to agree with those for the Dunagan apparatus.

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[1] Standard Method of Test for Approximate Apparent Specific Gravity of Fine Aggregates (A.S.T.M. Designation: C 68 – 30), see 1933 Book of A.S.T.M. Standards, Part II, p. 242.

In the second method the sample was thoroughly stirred about two minutes prior to each reading. Both the Dunagan apparatus and the Chapman flask were used. With the former, air bubbles were seen to escape from the sand when stirred the first five or six times. The results showed an increase in the specific gravity, indicating an absorption of water by the sand (Fig. 2). With the Chapman flask it was impossible to remove the entrapped air from the flask. The results were, therefore, in disagreement with those obtained with the Dunagan apparatus.

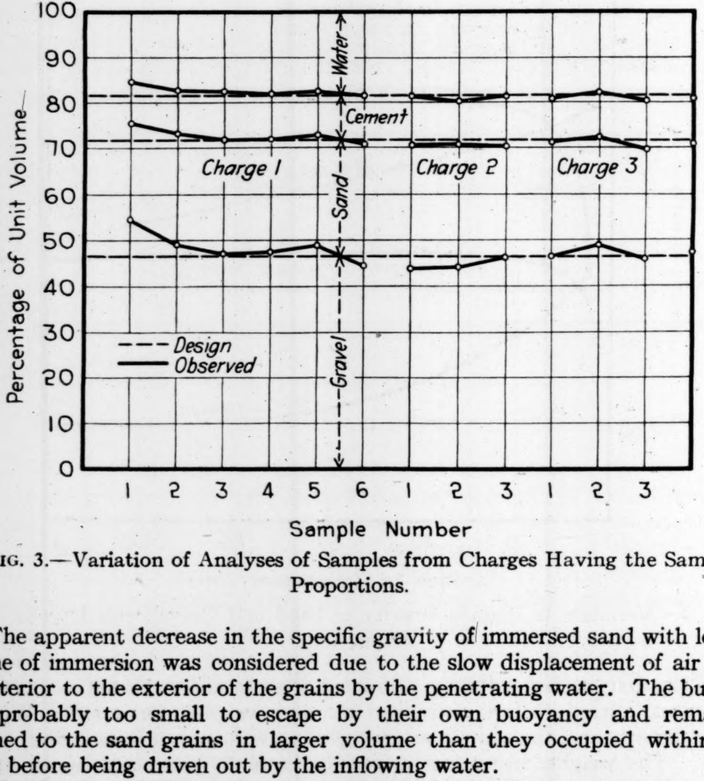

FIG. 3.—Variation of Analyses of Samples from Charges Having the Same Proportions.

The apparent decrease in the specific gravity of immersed sand with length of time of immersion was considered due to the slow displacement of air from the interior to the exterior of the grains by the penetrating water. The bubbles were probably too small to escape by their own buoyancy and remained attached to the sand grains in larger volume than they occupied within the grains before being driven out by the inflowing water.

The fineness of the sand was considered of great importance because the variation in the percentage of sand passing a No. 100 sieve (termed as silt) enters directly into the computation of an analysis made with the Dunagan apparatus. A variation of 1 per cent in the silt factor results in a change in the water content of 0.1 gal. or more per sack of cement for a 1:6 concrete mix having an actual water content of 7.5 gal. per sack of cement.

The sand used in this investigation contained only about 1.6 per cent silt.

Five samples of sand were sieved, both dry and wet. The results showed that dry sieving resulted in 0.3 per cent more silt passing the No. 100 sieve than did washing.

The amount of sand retained on the No. 4 sieve was of minor importance, because the vital ingredients of concrete (cement and water) are affected only when there is a considerable difference in the specific gravities of the fine and the coarse aggregates. The fine and coarse aggregates used in this study had approximately the same specific gravity.

Coarse Aggregate:

The tests on the coarse aggregate were conducted in the same manner as were those on the fine aggregate. The results of the specific gravity determination are plotted in Fig. 2 and show that the maximum variation was 0.4 per cent. Stirring at intervals during the period of immersion had no effect on the rate of absorption.

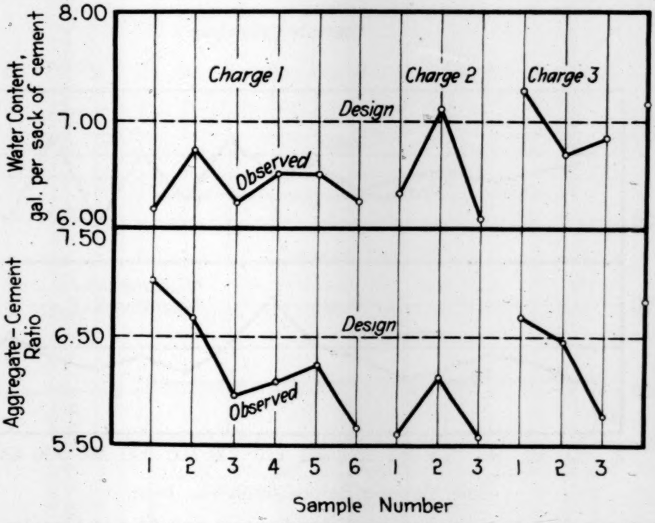

FIG. 4.—Series No. 1.—Variations of Water Content and Mix from Analyses of Samples from Charges Having the Same Proportions.

Tests were also made on the amount of coarse aggregate passing the No. 4 and No. 100 sieves. The percentages of coarse aggregate passing the No. 100 sieve varied from 0.2 to 0.6 per cent.

Concrete Mixes:

This investigation included five series of analyses of concrete mixes. In each series the results are believed to be representative of the adaptability of the Dunagan apparatus when used under some particular set of operating conditions.

Series No. 1 was made in the Fritz Engineering Laboratory of Lehigh University during the test of the Clinton Conveyor,[1] under circumstances closely approximating actual field conditions. An effort was made to secure representative samples weighing approximately 5000 g. each. The samples were weighed in air immediately and then set aside until it was convenient to analyze them. Corrections were made for the amount of aggregates passing and for the amount of cement retained on the No. 100 sieve. In Fig. 3 the results have been plotted on the basis of the volumetric composition of a unit volume of concrete. The extremely small scale used in this method of plotting fails to make evident the difference between the designed and the observed percentages of any one ingredient of the concrete. This is particularly unfortunate when the cement and the water are considered.

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[1] Willis A. Slater, "Tests of Concrete Conveyed from a Central Mixing Plant," *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part II, p. 510 (1931).

The results were therefore plotted in terms of designed and observed water contents and mixes (aggregate-cement ratio). Figure 3 shows close agreement between the designed and observed percentages of ingredients in a unit volume of concrete. Figure 4, however, shows that the water content differed as much as 1.0 gal. per sack of cement from the designed water content. The observed mix varied from 1:5.6 to 1:7.0, while the designed mix was 1:6.5.

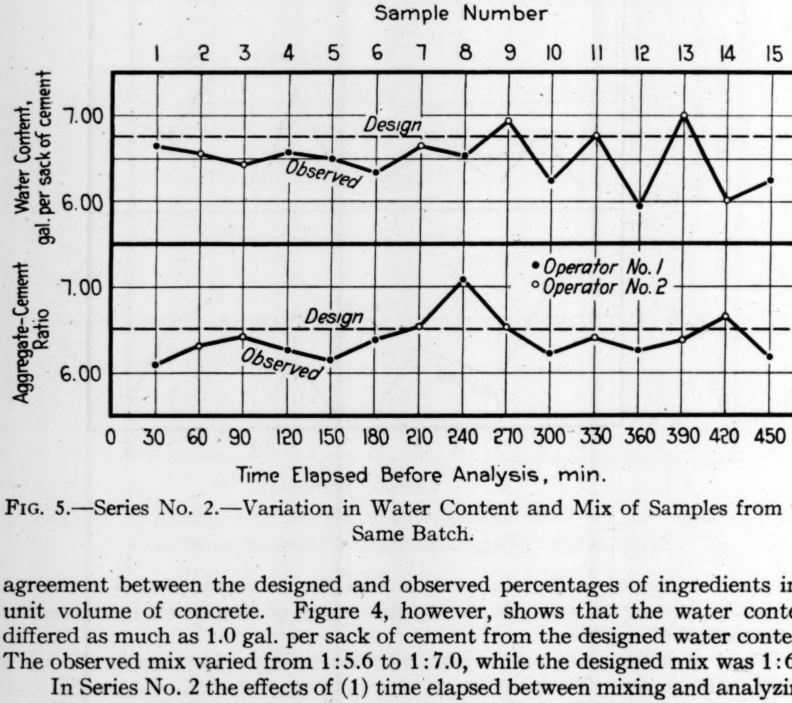

FIG. 5.—Series No. 2.—Variation in Water Content and Mix of Samples from the Same Batch.

In Series No. 2 the effects of (1) time elapsed between mixing and analyzing, and (2) personal equations of operators, were studied. These tests are assumed to be representative of results obtainable with the Dunagan apparatus under laboratory conditions. One cubic foot of concrete was divided into fifteen samples, all of which were weighed in air within ten minutes following the mixing. Corrections were made for cement retained on, and aggregates passing the No. 100 sieve. A correction was also made for the absorption of water by the aggregates. The results as plotted in Fig. 5 show a variation in the observed water content of 1.1 gal. per sack of cement. The designed mix was 1:6.5 and the observed mix varied from 1:6.1 to 1:7.1.

Little if any effect was found to be due to the personal equations of the two operators or to the time elapsed between mixing and analyzing.

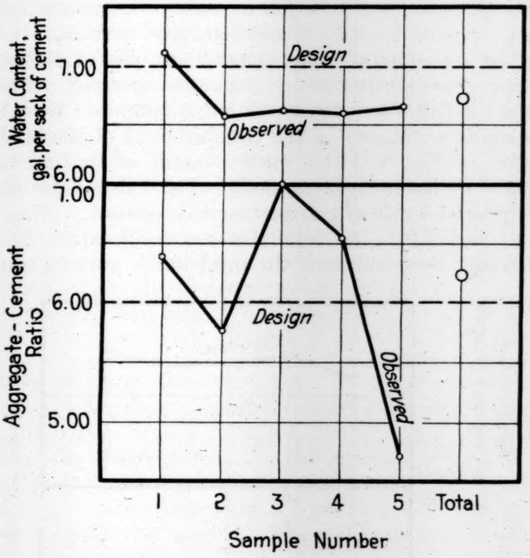

FIG. 6.—Series No. 3.—Variation in Ingredients as Determined from Samples from One Batch—Corrections Eliminated.

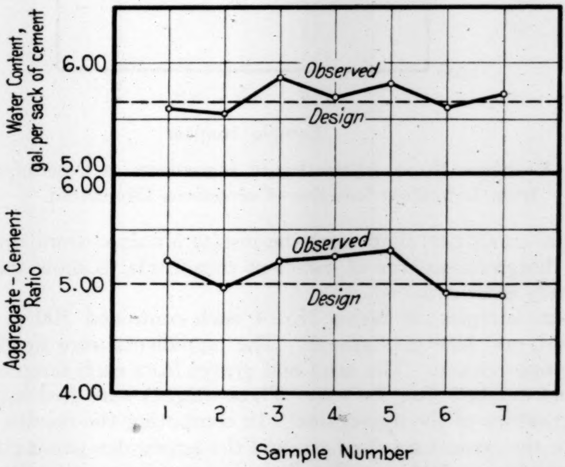

FIG. 7.—Series No. 4.—Variation in Water Content and Mix of Concrete Having Sampling Eliminated.

Series Nos. 3, 4 and 5 were made to determine the effect of sampling. In Series No. 3 the aggregates were washed in order to eliminate a silt correction. Saturated aggregate and absolute specific gravity were used to eliminate a correction for moisture content. The cement was passed through a No. 100 sieve, and all tests were performed by the same operator. The mixing was done by hand and the batch was divided into five samples. Both the individual and the total weights were used in the computations of the analyses and the results are plotted in Fig. 6. The water content of the individual samples showed a maximum variation from the designed of 0.45 gal. per sack of cement, while the total differed by 0.30 gal. per sack of cement. The observed mix varied from 1:4.7 to 1:7.0. The total mix was 1:6.2, while the designed mix was 1:6.0. Although the results for the total batch were in closer agreement with the actual conditions than were the results obtained from the individual samples, the disagreement was of sufficient magnitude to show that sampling was not the only error involved.

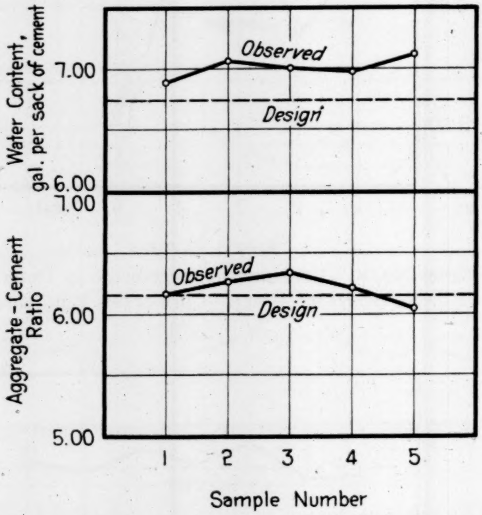

FIG. 8.—Series No. 5.—Variation in Ingredients as Determined from Individual Samples—Corrections Eliminated.

The seven samples in Series No. 4 each contained 500 g. of cement, 1000 g. of sand, and 1500 g. of gravel. The ingredients were weighed directly into the weighing bucket. The sand and gravel from each sample were dried thoroughly and weighed after the test. These weights were used in determining the specific gravities of the aggregates. In computing the results, corrections were made for the cement retained on, and the aggregates passing the No. 100 sieve. The results as plotted in Fig. 7 show a maximum variation of 0.3 gal. per sack of cement between the various samples, and 0.2 gal. per sack of cement from the water content used in the design of the mix. The designed mix was a 1:5.0 and the observed mix varied from 1:4.9 to 1:5.3.

In Series No. 5 variations in the fineness of the cement and aggregates, and in the method of sampling were eliminated. The cement had passed a

No. 100 sieve and the aggregates were retained on a No. 50 sieve. Both fine and coarse aggregates were washed and dried thoroughly before weighing. After weighing the aggregates were soaked for 48 hr. The cement was weighed in air and added to the saturated aggregates in the weighing bucket. In computing the results the absolute specific gravity of the aggregates was used. The value used for the specific gravity of the cement was that which corresponded to the time interval during which the cement had been immersed. The results as plotted in Fig. 8 show that discrepancies were not entirely eliminated, although every controllable variable had been taken into account. The only uncertain quantity in the analyses was the specific gravity of cement and the authors feel that they are justified in attributing the discrepancies primarily to this factor. The water content showed a variation of 0.35 gal. per sack of cement from the designed water content of 6.75 gal. per sack of cement. The designed mix was 1:6.5 and the observed mix varied from a 1:6.0 to a 1:6.3.

Effect of Errors on Analyses Results:

A study of the significant figures involved in the computation of the analyses of fresh concrete, revealed that a slide-rule computation was as accurate as warranted by the observations. If the specific gravity is determined to ±0.05, a variation in water content of as much as 0.7 gal. per sack of cement may be caused by the coarse aggregate, 0.5 gal. per sack by the fine aggregate, and 0.5 gal. per sack by the cement. These figures are based on a 1:2.4:3.6 mix.

DISCUSSION

MR. W. M. DUNAGAN.[1]—Two phases of this study by Messrs. Nettles and Holme require additional comment. They are: (*a*) that part of their paper dealing with phenomenon encountered in the use of the apparatus for specific gravity tests and (*b*) that part in which conclusions are stated relative to the accuracy of the test for analyzing samples of fresh concrete taken under practical mixing conditions. Their conclusions under both of these headings are subject to criticism from the fact that they are stated so as to apply only to the "Dunagan" method of test. The indications of accuracy which result from their study apply equally well to all methods for such test. This fact should enhance the value of their work to testing in general and a recognition of it should prevent a hasty review of their paper from damaging the usefulness of the buoyancy method alone.

Their specific gravity determinations were made by two methods; the results are compared in Figs. 1 and 2 of the paper. These figures clearly indicate substantially the same results by the two methods under comparable conditions. However, deviations are shown in both figures which the authors do not thoroughly explain; it should be pointed out that these deviations are not "deviations" from some standard of accuracy, that in fact they may be the "correct" values for the conditions of the test. In Fig. 1 the cement tests show that the specific gravity value decreases when the cement is stirred. This conclusion has no bearing upon the accuracy of the test. The situation is to be expected and such "stirring" has no parallel in the performance of the test under discussion.

In Fig. 2 the curves for sand, "stirred" and "unstirred," accurately represent an absorption rate for 1 per cent absorption over the period of time indicated. The adaptability of apparatus of this type for securing such data has caused many laboratories to use it especially for this purpose. Messrs. Nettles and Holme have again pointed out this usefulness. However, as pointed out by other discussions they have created an impression of actual variations from some correct specific gravity value by labelling their curves "variations in specific gravity," when the correct terms to have used should have been "variations in calculated value for the specific gravity."

The chief value of their data relative to specific gravity testing should be that of warning testing engineers as to the influence of the condition of the aggregate and their rate of absorption upon the value obtained as a specific gravity value.

In compiling Fig. 3, Messrs. Nettles and Holme have not availed themselves to the fullest extent of the data taken during Mr. W. A. Slater's study.[2] During this study at least 45 samples were taken that had a direct bearing upon the accuracy of the test for analysis of fresh concrete. Figure 3 presents but 14 of these tests. Thus their discussion presents conclusions based upon maximum deviations only. It is entirely possible that such "deviations" were not errors but exact tests. Such a discussion is not complete unless all data taken have been subjected to statistical analysis. Such an analysis may be made by the method presented by R. W. Crum.[3]

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[1] Associate Professor, Iowa State College, Ames, Iowa.

[2] W. A. Slater, "Tests of Concrete Conveyed from a Central Mixing Plant," *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part II, p. 510 (1931).

[3] R. W. Crum, "The Numbers of Specimens or Tests Required for a Reasonable Accuracy of the Average," Report on Significance of Tests of Concrete and Concrete Aggregates, issued as a separate Society publication.

The entire 45 tests from which the 14 shown in Fig. 3 were abstracted when subjected to Mr. Crum's method yield the following information. It is hoped that those particularly interested in the accuracy of this method of test will review these data carefully, with a review of the conditions under which they were taken.[1]

SUMMARY OF DEVIATIONS OF ANALYSIS OF SAMPLES OF FRESH CONCRETE TAKEN UNDER FIELD CONDITIONS.

Mix used, 1:2.33:4.14 (by weight), 7.0 gal.

A. Variation in samples taken from mixer:
1. Five mixer runs. 15 samples taken. (3 from each.)
2. Average mix found by test, 1:2.30:4.24, 6.98 gal.

3. Maximum deviation...	Aggregate...	0.89 parts by weight...	13.7 per cent
	Water.......	0.62 gal...............	11.2 per cent
4. Average deviation.....	Aggregate...	0.33 parts by weight...	5.1 per cent
	Water.......	0.35 gal...............	5.0 per cent
5. Standard deviation....	Aggregate...	0.45 parts by weight...	6.9 per cent
	Water.......	0.40 gal...............	5.7 per cent

B. Variation in samples taken when mixer runs were consolidated in a conveyor:
1. Five mixer runs. 30 samples taken.
2. Average mix found, 1:2.30:4.20, 6.61 gal.

3. Maximum deviation...	Aggregate...	0.46 parts by weight...	7.1 per cent
	Water.......	0.76 gal...............	11.5 per cent
4. Average deviation.....	Aggregate...	0.17 parts by weight...	2.65 per cent
	Water.......	0.26 gal...............	3.93 per cent
5. Standard deviation....	Aggregate...	0.24 parts by weight...	3.70 per cent
	Water.......	0.32 gal...............	4.90 per cent

These data are sufficient to establish the necessity for considering all data taken, not maximum deviations or averages. In the foregoing data the average of all specimens indicates an accuracy of 100 per cent while a fair value would be an average deviation of about 4 per cent in the use of this test.

Much valuable information might be presented in discussion of this paper. The subject "analysis of fresh concrete by any method" is almost as broad as the entire subject of the field control and proportioning of concrete. Since time does not permit the presentation of such data I wish to refer the reader to a recent publication, *Bulletin 113* of the Iowa Engineering Experiment Station[2] for more complete information and discussion of this subject matter.

Bulletin 113 presents a comprehensive review of the data taken by Mr. Slater[1] accompanied by supplementary data secured at Iowa State College. This publication attempts to cover the technique of making tests for the analysis of fresh concrete and to present solutions for problems encountered in the use of such a test. In this publication other phases of the work by Messrs. Nettles and Holme have been amplified.

The phenomenon connected with such a test as an analysis of fresh concrete are not confined to any particular method such as the one bearing the name of the discusser. It is hoped that the paper under discussion, this discussion of it and *Bulletin 113* will help to bring some of the points more forcibly before the Society for more critical study.

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[1] W. A. Slater, "Tests of Concrete Conveyed from a Central Mixing Plant," *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part II, p. 510 (1931).

[2] W. M. Dunagan, "A Proposed System for the Analysis and Field Control of Fresh Concrete," *Bulletin 113*, Iowa Engineering Experiment Station, Iowa State College (1933).

REPORT OF COMMITTEE C-10
ON
HOLLOW MASONRY BUILDING UNITS

Committee C-10 has held two meetings during the past year; one in Atlantic City on June 22, 1932, and one in New York City on March 9, 1933. Suggestions for changes in the standards for structural clay tile have originated from many sources within the industry and from consumers. These suggestions have been given careful consideration by the committee during the past year and have resulted in revisions being recommended in the standard specifications and definitions of terms relating to structural clay tile, as presented herewith.

Committee C-10 presented to the Society on August 6, 1931, through Committee E-10 on Standards, new Tentative Specifications and Tests for Load-Bearing Concrete Masonry Units (C 90 - 31 T) which were accepted for publication as tentative.[1] The tentative specifications were published in the 1931 *Proceedings*.[2]

The committee will recommend to the Society through Committee E-10 on Standards subsequent to the annual meeting a revision[3] in the methods of capping units for compressive strength tests as prescribed in the Tentative Specifications and Tests for Load-Bearing Concrete Masonry Units (C 90 - 31 T). The purpose of this proposed revision is to remove optional methods and to require the use of a single method. The proposed revision follows:

Section 17.—Change Paragraphs (*d*) and (*e*) from their present form: namely,

> (*d*) When the cement-gypsum cap is used it shall age at least six hours before the unit is tested. Where time is not available for aging the cement-gypsum cap, a cap of neat gypsum may be used. Where the neat gypsum cap is used the unit may be tested as soon as the plaster has been well set, but not sooner than one hour after the sample has been capped.
>
> (*e*) When sufficient time for hardening permits or when the surfaces of the samples are irregular, a capping of 1:2 portland-cement mortar may be used.

to read as follows:

> (*d*) The cap shall age at least six hours before the unit is tested.
>
> (*e*) When the specimens are made with irregular bearing surfaces, a 1:2 portland-cement mortar may be used to provide plane surfaces prior to capping.

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[1] In submitting these specifications to Committee E-10, the committee reported the results of the letter ballot vote as follows: 29 members returned their ballots, of whom 26 voted affirmatively and 3 negatively.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 781 (1931); also 1931 Book of A.S.T.M. Tentative Standards, p. 311.

[3] The revision was accepted and the revised specifications appear on p. 678. See Editorial Note, p. 310.—Ed.

RECOMMENDATIONS AFFECTING STANDARDS

The committee presents herewith revisions in the three existing standard specifications for structural clay tile under its jurisdiction and also presents revised definitions of the terms relating to structural clay tile. These revisions are recommended for publication as tentative in the form of separate tentative specifications and definitions appended hereto.[1] The four standards involved are as follows:

Standard Specifications and Tests for Structural Clay Load-Bearing Wall Tile (C 34 – 31);[2]

Standard Specifications and Tests for Structural Clay Fire proofing, Partition and Furring Tile (C 56 – 31);[2]

Standard Specifications and Tests for Structural Clay Floor Tile (C 57 – 31);[2] and

Standard Definitions of Terms Relating to Structural Clay Tile (C 43 – 31).[2]

The following general explanation is given concerning the tentative revisions which the committee is recommending in these standards:

Classification.—It has been found that the designations "Hard," "Medium" and "Soft" as applied to the classification of tile, though intended to be descriptive of quality are often misleading to purchasers. Furthermore, tile included in the two classifications now known as "Hard" and "Medium" are considered as meeting the weathering resistance under the standard specifications and are, therefore, used for the same purpose in construction. Because of these considerations, the committee recommends that the classifications be redesignated as "5–16" for the classes now known as "Hard" and "Medium" and "16–25" for the class now known as "Soft." The first and second figures of these designations represent the minimum and maximum average absorptions of five tests, respectively.

Size and Weight.—The present method of specifying sizes and weights of tile is out of date, as the tabulation in the present standard specifications does not include some of the most commonly used designs now manufactured. The committee feels it would be impracticable to catalog all of the special sizes, and is recommending that the tables on size and weight in the specifications be changed so as to cover in blanket form any size or shape manufactured to comply with the provisions of the A.S.T.M. standards.

Shell Thickness.—It is proposed that limitations be placed on the minimum shell thickness of end-construction load-bearing tile to afford a safeguard against the acceptance of units having shells too thin to provide satisfactory bed joints.

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[1] See pp. 667 to 683.—ED.

[2] 1931 Supplement to Book of A.S.T.M. Standards, pp. 43, 49, 53, 74, respectively.

Width of Cells.—The committee also recommends that a limit be placed on the ratio of the bearing shell thickness to width of cell in side-construction load-bearing tile as a basis for rejecting units which would tend to fail because of excessive bending stresses in the bearing shells.

Definitions.—Attempts have been made to write definitions for hollow masonry building units which would apply to both concrete masonry units and to structural clay tile, but the committee has now decided that this is impracticable. The Standard Definitions of Terms Relating to Structural Clay Tile (C 43 – 31) have been completely revised and several new definitions required by developments of the industry have been added. Subcommittee V on Definitions is at work on a separate set of definitions relating to concrete masonry units.

The recommendations appearing in this report have been submitted to letter ballot of the committee, which consists of 33 members, with the following results:

Item	Affirmative	Negative	Not Voting
I. PROPOSED REVISION OF STANDARDS			
Specifications and Tests for Structural Clay Load-Bearing Wall Tile (C 34 – 31)	20	2	1
Specifications and Tests for Structural Clay Fireproofing, Partition and Furring Tile (C 56 – 31)	20	2	1
Specifications and Tests for Structural Clay Floor Tile (C 57 – 31)	20	1	2
Definitions of Terms Relating to Structural Clay Tile (C 43 – 31)	22	0	1

This report has been submitted to letter ballot of the committee, which consists of 33 members; 21 members returned their ballots, of whom 18 have voted affirmatively and 3 negatively.

Respectfully submitted on behalf of the committee,

D. E. PARSONS,
Chairman.

F. E. EMERY,
Secretary.

EDITORIAL NOTE

The proposed revisions of the Standard Specifications and Tests for Structural Clay Load-Bearing Wall Tile, for Structural Clay Fireproofing, Partition and Furring Tile, for Structural Clay Floor Tile and Definitions of Terms Relating to Structural Clay Tile in the form of separate tentative standards, with modifications proposed on the floor of the annual meeting, see Summary of Proceedings, page 16, were accepted for publication as tentative and appear on pages 674, 671, 667 and 682, respectively.

Recommendation to Committee E-10 on Standards.—The revision of the Tentative Specifications and Tests for Load-Bearing Concrete Masonry Units, referred to in the report, was accepted on August 16, 1933, by Committee E-10 on Standards. The specifications in their revised form appear on page 678.

REPORT OF COMMITTEE C-11
ON
GYPSUM

Owing to the general conditions which prevailed during the past year, Committee C-11 on Gypsum has held no meetings since June, 1932. The committee, however, expects to resume active work in the fall. The following recommendations are made relative to the standards under the jurisdiction of the committee:

Tentative Methods of Testing Gypsum and Gypsum Products (*C 26 - 32 T*).[1]—These tentative methods were issued in 1932 as a tentative revision of the Standard Methods of Testing Gypsum and Gypsum Products (C 26 - 30),[2] after a thorough series of tests had been conducted which demonstrated the advisability of revising the standard methods. The revised methods have been tentative for one year, and the committee now recommends that they be adopted as standard to supersede the present standard methods. This recommendation has been referred to letter ballot of the committee, which consists of 28 members; 25 members returned their ballots, of whom 23 have voted affirmatively, 1 negatively and 1 member marked his ballot not voting.

Standard Specifications for Gypsum Partition Tile or Block (*C 52 - 27*).[3]—A tentative revision of this standard was submitted to the Society last year. The reasons for the changes proposed are given in the 1932 report of the committee.[4] The committee now recommends that this revision be advanced to standard. This recommendation has been referred to letter ballot of the committee, which consists of 28 members; 25 members returned their ballots, of whom 21 have voted affirmatively, none negatively and 4 members marked their ballots not voting.

The committee also recommends the withdrawal of the Standard Specifications for Gypsum Wall Board (C 36 - 25)[5] and for Gypsum Plaster Board (C 37 - 30).[5] These specifications have been replaced by the existing Tentative Specifications for Gypsum Wall Board (C 36 – 31 T)[1] and for Gypsum Lath (C 37 – 31 T).[1]

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 700 (1932); also 1932 Book of A.S.T.M. Tentative Standards, p. 354.

[2] 1930 Book of A.S.T.M. Standards, Part II, p. 125.

[3] *Ibid.*, p. 120.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, pp. 367, 995 (1932); also 1932 Book of A.S.T.M. Tentative Standards, p. 1139.

[5] 1930 Book of A.S.T.M. Standards, Part II, pp. 114, 117.

This report has been submitted to letter ballot of the committee which consists of 28 members; 25 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

J. W. GINDER,
Chairman.

H. J. SCHWEIM,
Secretary.

EDITORIAL NOTE

The Tentative Methods of Testing Gypsum and Gypsum Products were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1933. The methods which supersede the existing standard methods appear in the 1933 Book of A.S.T.M. Standards, Part II, page 96.

The tentative revision of the Standard Specifications for Gypsum Partition Tile or Block was approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1933. The specifications in their revised form appear in the 1933 Book of A.S.T.M. Standards, Part II, page 82.

The withdrawal of the Standard Specifications for Gypsum Wall Board and for Gypsum Plaster Board was approved subject to letter ballot of Committee C-11 which resulted favorably, see Summary of Proceedings, page 24, these specifications having been replaced by the existing Tentative Specifications for Gypsum Wall Board and for Gypsum Lath.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, pp. 740, 743 (1931); also 1932 Book of A.S.T.M. Tentative Standards, pp. 345, 348.

REPORT OF COMMITTEE D-1

ON

PRESERVATIVE COATINGS FOR STRUCTURAL MATERIALS

Committee D-1 on Preservative Coatings for Structural Materials held its meeting on March 30, 1933, at Hotel Raleigh, Washington, D. C., in conjunction with the meeting of the Paint and Varnish Division of the American Chemical Society. Subcommittee meetings were held during the two days prior to the meeting of the main committee.

A number of the subcommittees have been quite active during the past year, in their several lines of work, with the result that very complete reports were presented by them to Committee D-1.

Since the last annual meeting, 11 new members have been elected, 20 resignations have been accepted and 3 deaths reported, leaving a total membership of 174.

The work of the active subcommittees during the past year has resulted in the committee making the following recommendations to be acted upon at the annual meeting:

I. Eight new tentative specifications and one tentative method of test are being submitted;

II. A revision is proposed as tentative in one standard specification and a revision of one standard method of test is recommended for immediate adoption;

III. Revisions are proposed in one tentative specification and one tentative method of test;

IV. Eleven tentative specifications and one tentative method are recommended for advancement to standard without revision, three tentative specifications and one tentative method with revision;

V. Seven tentative revisions of existing standard methods are recommended for advancement to standard;

VI. Withdrawal is recommended of two standard specifications.

RECOMMENDATIONS AFFECTING STANDARDS

In this report, recommendations affecting standards and tentative standards are noted in brief form below, together with the results of the letter ballot. These recommendations are explained in the reports of the subcommittees directly responsible for them.

I. Proposed Tentative Standards.—The committee submits for publication as tentative, the following eight new specifications and one method of test, as appended hereto:

Tentative Specifications for Wood to be Used as Panels in Accelerated Weather Tests of Paints and Varnishes,[1] as proposed by Subcommittee VII;

Tentative Specifications for Spirits of Turpentine,[2] as proposed by Subcommittee XII;

Tentative Specifications for Shellac Varnish,[3] as proposed by Subcommittee XIII;

Tentative Specifications for Centrifuged Shellac Varnish,[4] as proposed by Subcommittee XIII;

Tentative Specifications and Methods of Test for Tricresyl Phosphate,[5] as proposed by Subcommittee XXV;

Tentative Specifications for Industrial 90 per cent Benzene (Benzol),[6] as proposed by Subcommittee XXV;

Tentative Specifications for Industrial Pure Toluene (Toluol),[7] as proposed by Subcommittee XXV;

Tentative Specifications for Industrial Xylene (Xylol) or Solvent Naphtha,[8] as proposed by Subcommittee XXV;

Tentative Methods of Test for Soluble Nitrocellulose Base Solutions,[9] as proposed by Subcommittee XXV.

II. Proposed Revisions of Existing Standards.—The committee recommends that the revisions in the Standard Specifications for Basic Carbonate White Lead (D 81 - 31),[10] as proposed by Subcommittee XV in its report appended hereto, be accepted for publication as tentative.

The committee further recommends that the revisions in Standard Methods of Sampling and Testing Turpentine (D 233 - 26),[11] as proposed by Subcommittee XII, be immediately adopted as standard. The committee accordingly asks for the necessary nine-tenths vote at the annual meeting in order that this revision may be submitted to letter ballot of the Society for immediate adoption.

III. Revisions of Tentative Standards.—The committee recommends that the following tentative specifications and tentative methods of test be revised as given in detail in the reports of the respective subcommittees and continued as tentative:

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[1] See p. 745.—ED. [2] See p. 725.—ED. [3] See p. 727.—ED

[4] See p. 729.—ED. [5] See p. 733.—ED. [6] See p. 731.—ED.

[7] See p. 732.—ED. [8] See p. 736.—ED. [9] See p. 737.—ED.

[10] 1931 Supplement to Book of A.S.T.M. Standards, p. 76

[11] 1930 Book of A.S.T.M. Standards, Part II, p. 337.

Tentative Specifications for Soya Bean Oil, Raw or Refined (D 124 - 22 T),[1] as proposed by Subcommittee III;

Tentative Methods of Testing Nitrocellulose Clear Lacquers and Lacquer Enamels (D 333 - 32 T),[2] as proposed by Subcommittee XXV.

IV. Advancement of Tentative Standards to Standard.—The committee recommends that the following tentative specifications and methods of test, with revisions as noted in the reports of the subcommittees, be advanced to standard:

Tentative Specifications for Raw Tung Oil (D 12 - 25 T),[3] as proposed by Subcommittee III;

Tentative Specifications for Boiled Linseed Oil (D 260 - 28 T),[4] as proposed by Subcommittee V;

Tentative Specifications for Dry Bleached Shellac (D 207 - 29 T),[5] with revision, as proposed by Subcommittee XIII;

Tentative Specifications for Orange Shellac (D 237 - 29 T),[5] with revision, as proposed by Subcommittee XIII;

Tentative Specifications for Pure Linseed Oil Putty for Glazing (D 317 - 32 T),[6] with revision, as proposed by Subcommittee XV;

Tentative Specifications for Soluble Nitrocellulose (D 301 - 31 T),[7] as proposed by Subcommittee XXV;

Tentative Specifications for Ethyl Acetate (85 to 88 per cent grade) (D 302 - 30 T),[8] as proposed by Subcommittee XXV;

Tentative Specifications for Normal Butyl Acetate (88 to 92 per cent grade) (D 303 - 30 T),[8] as proposed by Subcommittee XXV;

Tentative Specifications for Butanol (Normal Butyl Alcohol) (D 304 - 30 T),[8] as proposed by Subcommittee XXV;

Tentative Specifications for Amyl Acetate (Synthetic) (D 318 - 30 T),[8] as proposed by Subcommittee XXV;

Tentative Specifications for Amyl Alcohol (Synthetic) (D 319 - 30 T),[8] as proposed by Subcommittee XXV;

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 748 (1922); also 1932 Book of A.S.T.M. Tentative Standards, p. 482.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 742 (1932); also 1932 Book of A.S.T.M. Tentative Standards, p. 523.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 636 (1925); also 1932 Book of A.S.T.M. Tentative Standards, p. 473.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 864 (1928); also 1932 Book of A.S.T.M. Tentative Standards, p. 467.

[5] *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, pp. 637, 638 (1929); also 1932 Book of A.S.T.M. Tentative Standards, pp. 491, 492.

[6] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 736 (1932); also 1932 Book of A.S.T.M. Tentative Standards, p. 489.

[7] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 785 (1931); also 1932 Book of A.S.T.M. Tentative Standards, p. 493.

[8] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, pp. 1080, 1082, 1083, 1078, 1079 (1930); also 1932 Book of A.S.T.M. Tentative Standards, pp. 507, 509, 510, 505, 506.

Tentative Specifications for Butyl Propionate (90 to 93 per cent grade) (D 320 - 30 T),[1] as proposed by Subcommittee XXV;

Tentative Specifications for Ethyl Lactate (Synthetic) (D 321 - 30 T),[1] as proposed by Subcommittee XXV;

Tentative Specifications for Acetone (D 329 - 31 T),[2] as proposed by Subcommittee XXV;

Tentative Methods of Sampling and Testing Shellac (D 29 - 29 T),[3] with revision, as proposed by Subcommittee XIII;

Tentative Methods of Sampling and Testing Lacquer Solvents and Diluents (D 268 - 31 T),[4] as proposed by Subcommittee XXV.

V. Advancement to Standard of Tentative Revisions of Existing Standards.—The committee recommends that the tentative revisions[5] proposed last year of the following existing standards be advanced to standard:

Revision of Standard Methods of Routine Analysis of Dry Red Lead (D 49 - 29), as proposed by Subcommittee VIII;

Revision of Standard Methods of Routine Analysis of Yellow, Orange, Red and Brown Pigments Containing Iron and Manganese (D 50 - 27), as proposed by Subcommittee VIII;

Revision of Standard Method of Routine Analysis of Titanium Pigments (D 186 - 29), as proposed by Subcommittee VIII;

Revision of Standard Method of Routine Analysis of Dry Cuprous Oxide (D 283 - 29), as proposed by Subcommittee VIII;

Revision of Standard Method of Routine Analysis of Dry Mercuric Oxide (D 284 - 29), as proposed by Subcommittee VIII;

Revision of Standard Methods of Test for Hygroscopic Moisture (and Other Matter Volatile Under the Test Conditions) in Pigments (D 280 - 31), as proposed by Subcommittee VIII;

Revision of Standard Methods of Routine Analysis of White Pigments (D 34 - 30), as proposed by Subcommittee VIII.

VI. Withdrawal of Standards or Tentative Standards.—The committee recommends the withdrawal of the following standard specifications:

Standard Specifications for Gum Spirits of Turpentine and Steam-Distilled Wood Turpentine (D 13 - 26),[6] as proposed by Subcommittee XII;

Standard Specifications for Destructively Distilled Wood Turpentine (D 236 - 27),[6] as proposed by Subcommittee XII.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, pp. 1084, 1081 (1930); also 1932 Book of A.S.T.M. Tentative Standards, pp. 511, 508.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 796 (1931); also 1932 Book of A.S.T.M. Tentative Standards, p. 504.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 655 (1929); also 1932 Book of A.S.T.M. Tentative Standards, p. 526.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 799 (1931); also 1932 Book of A.S.T.M. Tentative Standards, p. 516.

[5] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, pp. 377, 1007 (1932); also 1932 Book of A.S.T.M. Tentative Standards, p. 1151.

[6] 1930 Book of A.S.T.M. Standards, Part II, pp. 300, 302.

The above recommendations have been submitted to letter ballot of the committee, which consists of 174 members; 59 members returned their ballots. The analysis of the vote of the committee is given in Table I.

TABLE I.—ANALYSIS OF LETTER BALLOT VOTE.

Items	Affirmative	Negative	Not Voting
I. PROPOSED TENTATIVE STANDARDS			
Specifications for Wood to be Used as Panels in Accelerated Weather Tests of Paints and Varnishes	43	0	16
Specifications for Spirits of Turpentine[a]	32	5	13
Specifications for Shellac Varnish	37	2	20
Specifications for Centrifuged Shellac Varnish	36	3	20
Specifications and Methods of Test for Tricresyl Phosphate	43	0	16
Specifications for Industrial 90 per cent Benzene (Benzol)	46	1	12
Specifications for Industrial Pure Toluene (Toluol)	48	0	11
Specifications for Industrial Xylene (Xylol) or Solvent Naphtha	48	0	11
Methods of Test for Soluble Nitrocellulose Base Solutions	41	1	17
II. PROPOSED REVISIONS OF EXISTING STANDARDS			
Specifications for Basic Carbonate White Lead (D 81 - 31)	43	0	16
Methods of Sampling and Testing Turpentine (D 233 - 26), immediate adoption	43	0	16
III. PROPOSED REVISIONS OF TENTATIVE STANDARDS			
Specifications for Soya Bean Oil, Raw or Refined (D 124 - 22 T)	41	0	18
Methods of Testing Nitrocellulose Clear Lacquers and Lacquer Enamels (D 333 - 32 T)	39	2	18
IV. ADVANCEMENT OF TENTATIVE STANDARDS TO STANDARD			
Specifications for Raw Tung Oil (D 12 - 25 T)	40	0	19
Specifications for Boiled Linseed Oil (D 260 - 28 T)	40	0	19
Specifications for Soluble Nitrocellulose (D 301 - 31 T)	38	0	21
Specifications for Ethyl Acetate (85 to 88 per cent grade) (D 302 - 30 T)	40	0	19
Specifications for Normal Butyl Acetate (88 to 92 per cent grade) (D 303 - 30 T)	40	0	19
Specifications for Butanol (Normal Butyl Alcohol) (D 304 - 30 T)	40	0	19
Specifications for Amyl Acetate (Synthetic) (D 318 - 30 T)	40	0	19
Specifications for Amyl Alcohol (Synthetic) (D 319 - 30 T)	40	0	19
Specifications for Butyl Propionate (90 to 93 per cent grade) (D 320 - 30 T)	40	0	19
Specifications for Ethyl Lactate (Synthetic) (D 321 - 30 T)	40	0	19
Specifications for Acetone (D 329 - 31 T)	40	0	19
Specifications for Dry Bleached Shellac (D 207 - 29 T), as revised	39	2	18
Specifications for Orange Shellac (D 237 - 29 T), as revised	38	2	19
Specifications for Pure Linseed Oil Putty for Glazing (D 317 - 32 T), as revised	38	1	20
Methods of Sampling and Testing Shellac (D 29 - 29 T), as revised	39	1	19
Methods of Sampling and Testing Lacquer Solvents and Diluents (D 268 - 31 T)	45	0	14
V. ADVANCEMENT TO STANDARD OF TENTATIVE REVISIONS OF EXISTING STANDARDS			
Standard Methods of Routine Analysis of Dry Red Lead (D 49 - 29)	42	0	17
Standard Methods of Routine Analysis of Yellow, Orange, Red and Brown Pigments Containing Iron and Manganese (D 50 - 27)	42	0	17
Standard Method of Routine Analysis of Titanium Pigments (D 186 - 29)	43	0	16
Standard Method of Routine Analysis of Dry Cuprous Oxide (D 283 - 29)	42	0	17
Standard Method of Routine Analysis of Dry Mercuric Oxide (D 284 - 29)	40	0	19
Standard Methods of Test for Hygroscopic Moisture (and Other Matter Volatile Under the Test Conditions) in Pigments (D 280 - 31)	41	0	18
Standard Methods of Routine Analysis of White Pigments (D 34 - 30)	41	0	18
VI. WITHDRAWAL OF STANDARDS			
Standard Specifications for Gum Spirits of Turpentine and Steam-Distilled Wood Turpentine (D 13 - 26)	42	2	15
Standard Specifications for Destructively Distilled Wood Turpentine (D 236 - 27)	42	2	15

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[a] The classified vote on the Tentative Specifications for Spirits of Turpentine was as follows: Affirmative: 15 producers, 11 consumers, 6 general interests; negative: 1 producer, 3 consumers, 1 general interest; not voting: 11 producers, 1 consumer, 1 general interest.

ACTIVITIES OF SUBCOMMITTEES

Appended hereto are reports of the following subcommittees:

Subcommittee XV on Specifications for Pigments Dry and In Oil When Marketed in That Form; and

Subcommittee XXV on Cellulose Ester Coatings.

In addition to the subcommittee reports appended, the activities of other subcommittees are reported as follows:

Subcommittee III on Testing of Paint Vehicles (H. A. Gardner, chairman).—This subcommittee recommends that the present Tentative Specifications for Raw Tung Oil (D 12 - 25 T) be advanced to standard, and that the Tentative Specifications for Soya Bean Oil, Raw or Refined (D 124 - 22 T) be continued as tentative with the following revision:

Title.—Change the title of these specifications to read as follows, by the addition of the italicized words and the omission of those in brackets:

> Tentative Specifications for [Soya Bean] *Raw Soybean* Oil [Raw or Refined].

Section 1.—Change this section to read as follows by the addition of the italicized words and the omission of those in brackets:

> 1. [Soya bean] *Raw Soybean* oil [raw or refined] shall conform to the following requirements:

In the table of requirements make the following changes:

Decrease the maximum limit for loss on heating at 105 to 110 C. from "0.2 per cent" to read "0.1 per cent."

Decrease the maximum limit for acid number from "5.0" to read "3.0."

Change "Iodine number (Hanus), 128, minimum," to read "Iodine number (Wijs), 131 minimum."

Omit the property "unsaponifiable matter" and the requirement of "1.5 per cent maximum."

Change the requirement for color to read as follows, by the addition of the italicized words and the omission of the word in brackets:

> Not darker than a freshly prepared solution of 1.0 g. potassium [bichromate] *dichromate* in 100 cc. pure H_2SO_4 (sp. gr. 1.84) *or its equivalent in iron-cobalt solution.*

Subcommittee V on Linseed Oil (R. D. Bonney, chairman).—This subcommittee recommends that the Tentative Specifications for Boiled Linseed Oil (D 260 - 28 T) be advanced to standard. In the 1932 report of the subcommittee,[1] reference is made to the abnormal condition in Argentine flaxseed in the 1931 crop, which resulted in linseed oil with an excessively high acid number, calling attention to the fact that some of this oil, while undoubtedly pure linseed oil, was outside the quality specifications of the A.S.T.M. This year the subcommittee has another abnormal condition to report, namely, that considerable of the oil crushed from domestic linseed is slightly below the minimum iodine value set by A.S.T.M. specifications. This condition appears to be due to two causes. First, abnormal weather conditions which resulted in premature harvesting, and second, the extensive planting of a type of flaxseed which produced oil with an iodine value lower than other types of seed. It is reported that those interested in flax development are taking steps to discourage the planting of the type of seed which produces oil with low iodine value. It is also improbable that weather conditions similar to those of last year will occur very often. While the subcommittee has no recommendation to make with respect to this matter, it desires to indicate that some of the linseed oil now on the market may be pure linseed oil and still be below the A.S.T.M. specifications for quality.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 373 (1932).

Subcommittee VII on Accelerated Tests for Protective Coatings (H. A. Nelson, chairman).—This subcommittee recommends for publication as tentative, the proposed Specifications for Wood to be Used as Panels in Accelerated Weather Tests of Paints and Varnishes, as appended hereto.[1] This recommendation is made after successfully employing these specifications during the past year and after they had been referred to Subcommittee I, of Committee D-7, on Specifications for Timber. This subcommittee has been actively engaged in an attempt to reorganize into five groups. Groups 3 on Varnishes and 5 on Panel Specifications are now functioning, and the organization of the others will be completed in the immediate future. New members, particularly representatives of large consumers, are being sought to serve on these groups. Contact has been established with Subcommittee VIII, of Committee D-8, on Accelerated Weather Tests for Bituminous Materials.

Subcommittee VIII on Methods of Analysis of Paint Materials (G. F. A. Stutz, chairman).—This subcommittee recommends that the tentative revisions proposed last year of the following standard methods be advanced to standard:

Standard Methods of Routine Analysis of Dry Red Lead (D 49 – 29);

Standard Methods of Routine Analysis of Yellow, Orange, Red and Brown Pigments Containing Iron and Manganese (D 50 – 27);

Standard Method of Routine Analysis of Titanium Pigments (D 186 – 29);

Standard Method of Routine Analysis of Dry Cuprous Oxide (D 283 – 29);

Standard Method of Routine Analysis of Dry Mercuric Oxide (D 284 – 29);

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[1] See p. 745.—ED.

Standard Methods of Test for Hygroscopic Moisture (and Other Matter Volatile Under the Test Conditions) in Pigments (D 280 – 31); and

Standard Methods of Routine Analysis of White Pigments (D 34 – 30).

This subcommittee recommends that the tentative revisions of the following standard methods be continued as tentative:

Standard Methods of Routine Analysis of White Linseed Oil Paints (D 215 – 29);

Standard Methods of Routine Analysis of Yellow and Orange Pigments Containing Chromium Compounds, Blue Pigments and Chrome Green (D 126 – 27).

Since the Tentative Specification for the Testing of Dry Color Shipments, submitted by the Dry Color Committee of the Federation of Paint and Varnish Production Clubs, is at variance with the Tentative Method of Test for the Tinting Strength of White Pigments (D 332 – 31 T), it is impossible for this subcommittee to endorse the specification. In their opinion, a standard method of test for the strength of colored pigments should be drawn up, and the subcommittee proposes to prepare such a method of test, based on the specification for the testing of dry color shipments.

Subcommittee IX on Varnish (W. T. Pearce, chairman).—This subcommittee reports outline of work to be completed during the coming year on the development and standardizing of methods for: (1) determining acid values, (2) a test for alkali resistance, (3) a test for skinning, and (4) an adhesion test.

Subcommittee XI on Paint Thinners Other Than Turpentine (Lyman Quincy, chairman).—This subcommittee, while realizing that the Tentative Specifications for Petroleum Spirits (Mineral Spirits) (D 235 – 26 T) has been in a tentative status for more than three years, advises that it be continued as tentative until definite recommendations can be developed after an investigation of the following: Requirement for a satisfactory method and specification for that quality of mineral thinners commonly called solvency. Plans will be made to investigate details of the various methods in common use, such as the Kauri butanol test and toluol modification test. Consideration will be given the aniline method, dimethyl sulfate method and various varnish and treated oil reduction tests. Owing to some discussion regarding the permitted distillation range, this subject will be considered, and also the question of sulfur tests. In addition to the above, this committee recognizes that a demand exists for an A.S.T.M. specification covering the petroleum distillate commonly known as "Varnish Makers and Painters Naphtha" (V. M. & P.), and plans to investigate possibilities for establishing such a specification. Allied petroleum products commonly known as "Lacquer Diluents" may also be studied in collaboration with Group 2 of Subcommittee XXV.

Subcommittee XII on Turpentine (F. P. Veitch, chairman).—This subcommittee has given further consideration to the matter of standard specifications for the several kinds of spirits of turpentine and the methods of sampling and testing turpentine. Thorough discussion of this matter by the committee resulted in the preparation of proposed Tentative Specifications for Spirits of Turpentine appended hereto.[1] These specifications cover gum spirits of turpentine, steam-distilled wood turpentine, sulfate wood turpentine and destructively-distilled wood turpentine. It is recommended that these specifications be issued as tentative to supersede the present Standard Specifications for Gum Spirits of Turpentine and Steam-Distilled Wood Turpentine (D 13 - 26) and Standard Specifications for Destructively Distilled Wood Turpentine (D 236 - 27). It is accordingly recommended that the Standard Specifications D 13 and D 236 be discontinued.

The subcommittee recommends for immediate adoption the following changes in the Standard Methods of Sampling and Testing Turpentine (D 233 - 26):

Section 4: Color.—For purpose of providing an alternate procedure in the color test, add the following sentences at the end of this section:

> Or, compare the color of the sample in any suitable apparatus with the color of an equal depth of a fresh solution of potassium bichromate in distilled water, containing 0.0180 g. of potassium bichromate per liter. If the sample is as light as, or lighter than, the bichromate solution, the turpentine is "Standard" or better.

Section 9: Operation.—Change the first sentence to read as follows by the omission of the words in brackets:

> Place 100 cc. of the turpentine and several small pieces of pumice (or glass) in the distilling flask, fit the thermometer so that the top of the mercury bulb is level with the bottom of the side tube [and the 175° C. mark is below the cork].

Change the last sentence to read as follows by the addition of the italicized words and figures and the omission of the figures in brackets:

> Discontinue distillation when the temperature reaches [170° C.,] *that specified for the 90-per-cent point* or an equivalent thereof, depending on the atmospheric pressure, as described in Section 10; let the condenser drain and read the percentage distilled.

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[1] See p. 725.—ED.

Subcommittee XIII on Shellac (J. W. Paisley, chairman).—This subcommittee recommends for publication as tentative, new Specifications for Shellac Varnish and for Centrifuged Shellac Varnish as appended hereto.[1] It has been felt by this subcommittee for several years that there was need for specifications for shellac varnish, and in consequence these have now been developed. The present specifications for shellac varnish and centrifuged shellac varnish are the result of a careful review of this subject by this subcommittee. Two specifications are presented in order to meet several objections raised against the specification advanced last year and withdrawn at the June meeting by this subcommittee. Certain changes have also been incorporated to meet various objections that have been called to this committee's attention. These new specifications are now unanimously recommended by the subcommittee. The Tentative Methods of Sampling and Testing Shellac (D 29 – 29 T) have been tentative for a number of years with but little revision. During this time, practical use of these methods has developed several refinements which are essential for efficiency and accuracy. This subcommittee has completely reviewed these methods in their entirety and unanimously recommends the extensive revision which incorporates these details. Sections have been rewritten for the sake of clarity, and objections which were advanced against last year's recommendations have been met. Certain features of the Tentative Methods D 29 are considered to be unsatisfactory, and in consequence this subcommittee recommends changes as appended hereto[2] which include modifications in the test for insoluble matter, methods for determining wax, iodine number, drying time and nature of volatile matter. This subcommittee recommends that the methods as revised be adopted as standard.[2] This subcommittee is also recommending, as mentioned earlier in this report, that the Tentative Specifications for Dry Bleached Shellac (D 207 – 29 T) and Specifications for Orange Shellac (D 237 – 29 T) be advanced to standard with the following revision: Change the requirement "matter insoluble in hot alcohol" to read "matter insoluble in specified hot solvents."

This subcommittee reports that Committee D-9 on Electrical Insulating Materials has been asked to undertake the development of tests for shellac and synthetic resins as electrical insulating materials, and that to carry out this work Committee D-9 has formed a new section of its Subcommittee I on Insulating Varnishes, Paints and Lacquers, which deals with insulating varnishes, to cooperate with

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[1] See pp. 727, 729.—ED

[2] The revised methods appear in the 1933 Book of A.S.T.M. Standards, Part II, p. 678—ED.

Subcommittee XIII of Committee D-1. At a meeting held on March 15, Mr. L. J. Cavanaugh was appointed chairman of this new Section on Shellac. Members of Committee D-1 who were present signified their intention of seeking membership on this new section.

Subcommittee XVIII on Physical Properties of Materials (F. P. Ingalls, chairman).—This subcommittee plans to give a somewhat detailed study to the property designated as gloss. It is planned to first endeavor to define gloss, together with its modifying terms with respect to paints, varnishes and lacquers, and then to present the best available method or methods of giving it a quantitative value.

This report has been submitted to letter ballot of the committee, which consists of 174 members; 59 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

ALLEN ROGERS,
Chairman.

M. REA PAUL,
Secretary.

EDITORIAL NOTE

The proposed Tentative Specifications for Wood to be Used as Panels in Accelerated Weather Tests of Paints and Varnishes, Specifications for Spirits of Turpentine, for Shellac Varnish, for Centrifuged Shellac Varnish, for Industrial 90 per cent Benzene (Benzol), for Industrial Pure Toluene (Toluol), for Industrial Xylene (Xylol) or Solvent Naphtha, Specifications and Methods of Test for Tricresyl Phosphate, and Tests for Soluble Nitrocellulose Base Solutions were accepted for publication as tentative and appear on pages 725 to 745.

The revision proposed for immediate adoption in the Standard Methods of Sampling and Testing Turpentine was approved at the annual meeting by a unanimous vote and was subsequently adopted by letter ballot of the Society on September 1, 1933. The methods in their revised form appear in the 1933 Book of A.S.T.M. Standards, Part II, page 668.

The proposed revision of the Standard Specifications for Basic Carbonate White Lead was accepted for publication as tentative and appears on page 1036.

The proposed revisions of the Tentative Specifications for Soya Bean Oil, Raw or Refined, and of the Tentative Methods of Testing Nitrocellulose Clear Lacquers and Lacquer Enamels were accepted. The specifications and methods in their revised form appear on pages 720 and 741, respectively.

The Tentative Specifications for Raw Tung Oil, for Boiled Linseed Oil, for Soluble Nitrocellulose, for Ethyl Acetate (85 to 88 per cent grade), for Normal Butyl Acetate (88 to 92 per cent grade), for Butanol (Normal Butyl Alcohol), for Amyl Acetate (Synthetic), for Amyl Alcohol (Synthetic), for Butyl Propionate (90 to 93 per cent grade), for Ethyl Lactate (Synthetic), for

Acetone, for Dry Bleached Shellac, as revised, for Orange Shellac, as revised, for Pure Linseed Oil Putty for Glazing, as revised; also Tentative Methods of Sampling and Testing Shellac, as revised, and Sampling and Testing Lacquer Solvents and Diluents were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1933. The standards appear in the 1933 Book of A.S.T.M. Standards, Part II, pages 638 to 730.

The tentative revisions of the Standard Methods of Routine Analysis of Dry Red Lead, of Yellow, Orange, Red and Brown Pigments Containing Iron and Manganese, of Titanium Pigments, of Dry Cuprous Oxide, of Dry Mercuric Oxide, of White Pigments, and Test for Hygroscopic Moisture (and Other Matter Volatile Under the Test Conditions) in Pigments were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1933. The methods in their revised form appear in the 1933 Book of A.S.T.M. Standards, Part II, pages 553 to 637.

The withdrawal of the Standard Specifications for Gum Spirits of Turpentine and Steam-Distilled Wood Turpentine and for Destructively Distilled Wood Turpentine was approved.

REPORT OF SUBCOMMITTEE XV ON SPECIFICATIONS FOR PIGMENTS DRY AND IN OIL WHEN MARKETED IN THAT FORM

During the past year Subcommittee XV has given consideration to the various specifications under its jurisdiction and makes the following recommendations:

Tentative Specifications for Pure Linseed Oil Putty for Glazing (D 317 - 32 T).[1]—The subcommittee has continued its study of these tentative specifications, particularly with reference to the pigment. Large quantities of glazier's putty are made from calcium carbonates other than chalk whiting and serve the purpose satisfactorily. It is, however, necessary to guard against ground, crystalline marble and limestone because these will not give the proper texture and plasticity. The subcommittee therefore recommends that the reference to chalk whiting be omitted from the specifications and the specifications as thus revised be submitted to the Society for adoption as standard. The revision proposed is as follows:

Section 3. (b).—Change from its present form: namely,

> (*b*) *Whiting.*—The whiting used in both classes of putty shall be a finely powdered natural chalk of high grade. It shall be free from grit and be practically neutral. It shall have the structure and other physical characteristics of the best natural whiting suitable for putty making.

to read as follows:

> (*b*) *Whiting.*—The whiting used in both classes of putty shall be free from grit, shall be practically neutral and shall have a structure and physical characteristics adapted to the manufacture of putty of the required physical properties.

Standard Specifications for Basic Carbonate White Lead (D 81 - 31).[2]—Recently, a new variety of semipaste white lead has become prominent on the market. It contains only a minimum of oil and the soft consistency is obtained by the addition of a small amount of turpentine. This permits the manufacture of flat drying paints without the use of the stiff paste white lead. It is desired to provide tentatively for the new material in the specifications. The subcommittee accordingly recommends that the following revision of these standard specifications be accepted for publication as tentative:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 736 (1932); also 1932 Book of A.S.T.M. Tentative Standards, p. 489.

[2] 1931 Supplement to Book of A.S.T.M. Standards, p. 76.

Section 3.—Add the following to this section as a new Paragraph (*e*):

(*e*) *Semipaste Containing Volatile Thinner.*—The semipaste shall not be caked in the container and shall be readily stirred to a uniform mixture which shall mix readily with oil, turpentine, or mineral spirits to form a smooth paint of brushing consistency. The odor of the semipaste, as taken from the container, while drying or after drying, shall be not abnormally pungent or disagreeable.

The semipaste shall conform to the following requirements:

	MAXIMUM	MINIMUM
Pigment, per cent	....	87.5
Linseed oil, per cent	10.5	....
Volatile matter[a] and moisture, per cent	3.0	1.5
Moisture, per cent	0.7	....
Coarse particles and skins (total residue retained on a No. 325 sieve), per cent of the dry pigment	1.5	....

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[a] The volatile matter shall be turpentine, mineral spirits, or any mixture thereof.

Respectfully submitted on behalf of the subcommittee,

H. E. SMITH,
Chairman.

REPORT OF SUBCOMMITTEE XXV ON CELLULOSE ESTER COATINGS

Subcommittee XXV has been very active during the year and has prepared five new specifications and tests for solvents and has also reviewed the various specifications and methods of test under its jurisdiction which have resulted in the recommendations proposed in this report.

Proposed Tentative Standards.—The subcommittee recommends for publication as tentative the following four specifications and one method of test, as appended hereto:[1]

- Proposed Tentative Specifications for Industrial 90 per cent Benzene (Benzol)
- Proposed Tentative Specifications for Industrial Pure Toluene (Toluol)
- Proposed Tentative Specifications for Industrial Xylene (Xylol) or Solvent Naphtha
- Proposed Tentative Specifications and Methods of Test for Tricresyl Phosphate
- Proposed Tentative Methods of Test for Soluble Nitrocellulose Base Solutions

Proposed Revision of Tentative Standard.—The subcommittee recommends that the Tentative Methods of Testing Nitrocellulose Clear Lacquers and Lacquer Enamels (D 333 - 32 T)[2] be revised as follows and continued as tentative:

Section 9.—Change the first sentence of the first paragraph to read as follows by the addition of the italicized words and the omission of those in brackets:

> 9. Weigh into [an aluminum] *a flat-bottom metal or glass* dish containing a stirring rod, from 4 to 6 g. of the sample to be tested, *weighing in such a manner as to minimize the loss of volatile solvents.*

Change the second paragraph of Section 9 to read as follows by the addition of the italicized words:

> The method of determining non-volatile matter in varnishes, as described in Sections 6 and 7 of the Standard Methods of Testing Oleo-Resinous Varnishes (A.S.T.M. Designation: D 154) of the American Society for Testing Materials, may be used if mutually agreed upon by the buyer and seller *with the additional requirement that the sample shall be reheated and reweighed until the weight is constant to within 0.001 g.*

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[1] See pp. 731 to 740.— Ed.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 742 (1932); also 1932 Book of A.S.T.M. Tentative Standards, p. 523.

Consistency Test.—The subcommittee recommends that the proposed method and apparatus for the determination of the consistency of nitrocellulose clear lacquers and lacquer enamels, as appended hereto,[1] be added to the Tentative Methods D 333 as Sections 10 and 11. This proposed method was published last year in the report of the subcommittee as information.[2]

Advancement to Standard of Tentative Standards.—The subcommittee recommends that the following nine tentative specifications and one method of test, under its jurisdiction, be advanced to standard:

Tentative Specifications and Tests for Soluble Nitrocellulose (D 301 - 31 T)[3]
Tentative Specifications for Ethyl Acetate (85 to 88 per cent Grade) (D 302 - 30 T)[4]
Tentative Specifications for Normal Butyl Acetate (88 to 92 per cent Grade) (D 303 - 30 T)[4]
Tentative Specifications for Butanol (Normal Butyl Alcohol) (D 304 - 30 T)[4]
Tentative Specifications for Amyl Acetate (Synthetic) (D 318 - 30 T)[4]
Tentative Specifications for Amyl Alcohol (Synthetic) (D 319 - 30 T)[4]
Tentative Specifications for Butyl Propionate (90 to 93 per cent Grade) (D 320 - 30 T)[4]
Tentative Specifications for Ethyl Lactate (Synthetic) (D 321 - 30 T)[4]
Tentative Specifications for Acetone (D 329 - 31 T)[3]
Tentative Methods of Sampling and Testing Lacquer Solvents and Diluents (D 268 - 31 T)[3]

Proposed Revision of Standard.—In connection with some work undertaken in cooperation with the Solvents Institute, Inc., about two years ago to establish definitely the flash points of several of the common lacquer solvents, it developed that the Standard Method of Test for Flash Point of Volatile Flammable Liquids (D 56 - 21)[5] is open to several objections and cannot be followed exactly in the determination of the flash points of some of the more common lacquer solvents. To make the procedure applicable to such cases no changes in the requirements for the apparatus are required except with respect to the temperature range covered by the thermometer, and only slight changes in the directions for carrying out the test are needed. For the purposes of a general method for determining the flash points of lacquer solvents and diluents, Method D 56, as it stands at the present time, is open to the following objections:

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[1] See p. 743.—ED.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 392 (1932).

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, pp. 785, 796, 799 (1931); also 1932 Book of A.S.T.M. Tentative Standards, pp. 493, 504, 516.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, pp. 1080, 1082, 1083, 1078, 1079, 1084, 1081 (1930); also 1932 Book of A.S.T.M. Tentative Standards, pp. 507, 509, 510, 505, 506, 511, 508.

[5] 1930 Book of A.S.T.M. Standards, Part II, p. 362.

1. The instructions in Section 3 covering the water bath cannot be followed for liquids having flash points below 52 F., inasmuch as it would require the use of water in the cooling bath at a temperature below its freezing point.

2. The specifications for the thermometer are such that the instructions with respect to the temperature of the cooling bath, and of the liquid to be tested, cannot be accurately followed for liquids having flash points below 40 F.

3. Throughout the procedure the liquid under test is referred to as "oil." In testing lacquer solvents or diluents a more general term seems desirable.

4. It is thought that the results obtained when using a gas flame will be more nearly comparable with those obtained when oil is used if the use of a luminous gas flame were specified.

Each of the above objections has received the consideration of the subcommittee. The following proposed changes of this method are accordingly recommended for publication as information:

Section 1 (c).—The present method specifies a thermometer graduated in either Centigrade or Fahrenheit degrees, as specified, the ranges being −7 to +110 C. or +20 to +230 F., respectively. In testing certain of the lower flashing lacquer solvents it is necessary to use a thermometer graduated about 20 F. lower. It is accordingly recommended that provision be made in Method D 56 for a thermometer graduated in either Centigrade or Fahrenheit, as specified, the ranges being −17.7 C. to 100 C. or 0 F. to 210 F., respectively. The other requirements of the thermometers at present specified in the Standard Method D 56, such as, the type, liquid used, graduation, etc., shall also apply to these new thermometers with suitable changes to provide for the different temperature range.

Section 2 (a).—At the end of this paragraph add the following sentence:

When gas is used the flame should be luminous in order that the results will be comparable with those obtained when oil is used.

Section 3.—Change from its present form: namely,

3. Put the water-bath thermometer in place, and put a receptacle under the overflow spout to catch the overflow. Fill the water bath with water at such a temperature that, when testing is started, the temperature of the water bath will be at least 20 F. (11 C.) below the probable flash point of the oil to be tested.

to read as follows:

3. Put the water-bath thermometer in place, and put a receptacle under the outflow spout to catch the overflow. Fill the bath with water or brine

at such a temperature that, when testing is started, the temperature of the bath will be 10 to 20 F. (5 to 11 C.) below the probable flash point of the liquid to be tested.

NOTE.—The approximate temperature of the brines which will be obtained by mixing various proportions of sodium chloride (NaCl) or calcium chloride crystals ($CaCl_2.6H_2O$) with snow or crushed ice is given below:

PARTS $CaCl_2.6H_2O$ PER 100 PARTS SNOW OR CRUSHED ICE.	TEMPERATURE		PARTS NaCl PER 100 PARTS SNOW OR CRUSHED ICE.	TEMPERATURE	
	DEG. CENT.	DEG. FAHR.		DEG. CENT.	DEG. FAHR.
20	−4	+25	10	−5	+23
40	−9	+16	20	−10	+14
60	−14.5	+ 6	27	−15	+ 5
80	−21	− 6	33	−21	− 6
100	−29	−20			

Section 4.—Change the first three sentences of this section to read as follows by the addition of the italicized words and figures and the omission of the words in brackets:

4. Put the [oil] cup in place in the [water] bath. Measure 50 ml. of the [oil] *liquid* to be tested in a pipette or a graduate, and place in the [oil] cup. The temperature of the [oil] *liquid* shall be [at least] *10 to* 20 F. (*5 to* 11 C.) below its probable flash point when testing is started.

Section 5.—Change the second sentence of this section to read as follows by the addition of the italicized word and the omission of the word in brackets:

Adjust the flame of the alcohol lamp so that the temperature of the [oil] *sample* in the cup rises at the rate of about 1.8 F. (1 C.) per minute, not faster than 2 F. (1.1 C.) nor slower than 1.6 F. (0.9 C.) per minute.

Section 6.—Change Paragraph (*b*) and the first sentence of Paragraph (*c*) to read as follows by the addition of the italicized words and the omission of those in brackets:

(*b*) Record the temperature of the [oil] sample at start.

(*c*) When the temperature of the [oil] *liquid* reaches 9 F. (5 C.) below [the] *its* probable flash point [of the oil], turn the knob on the cover so as to introduce the test flame into the cup, and turn it promptly back again.

Change Paragraphs (*e*) and (*f*) to read as follows by the addition of the italicized word and the omission of those in brackets:

(*e*) Record the temperature of the [oil] sample at the time of first test.

(*f*) Repeat the application of the test flame at every 1 F. (0.5 C.) rise in temperature of the [oil] *liquid* until there is a flash [of the oil] within the cup.

Change the first sentence of Paragraph (*i*) to read as follows by the addition of the italicized word and the omission of the word in brackets:

(*i*) If the rise in temperature of the [oil] *sample* from the "time of making the first introduction of the test flame" to the "time at which the flash point is reached" was faster than 2 F. (1.1 C.) or slower than 1.6 F. (0.9 C.) per minute, the test should be questioned, and the alcohol heating lamp adjusted to correct the rate of heating.

Section 7.—Change Paragraphs (*b*), (*c*) and (*d*) to read as follows by the addition of the italicized words and the omission of those in brackets:

(*b*) Having completed the preliminary test, remove the heating lamp, lift up the [oil] cup cover, and wipe off the thermometer bulb. Lift out the [oil] cup, and empty and carefully wipe it. Throw away all [oil] samples after once used in making a test.

(*c*) Pour cold water *or brine* into the [water] bath, allowing it to overflow into a receptacle, until the temperature of the [water in the] bath is lowered to 15 F. (8 C.) below the flash point of the [oil] *liquid*, as shown by the previous test.

(*d*) Place the [oil] cup back in the bath and measure into it a 50-ml. charge of fresh [oil] *liquid*. Destroy any bubbles on the surface of the [oil] *liquid*, put on the cover with its thermometer, put in the heating lamp, record the temperature of the [oil] *liquid*, and proceed to repeat the test as described above in Sections 4 to 6, inclusive. Introduce the test flame for first time at a temperature of 10 F. (5.5 C.) below the flash point obtained on the previous test.

Respectfully submitted on behalf of the subcommittee,

R. M. CARTER,
Chairman.

REPORT OF COMMITTEE D-2
ON
PETROLEUM PRODUCTS AND LUBRICANTS

Committee D-2 on Petroleum Products and Lubricants held three regular meetings during the past year (in June at Atlantic City, N. J., in January at Washington, D. C., and in March in New York, N. Y.) and also an informal meeting in November at Houston, Texas, at the time of the annual meeting of the American Petroleum Institute.

During the year, a new Subcommittee X on Sligh Oxidation Test was authorized and appointed under the chairmanship of O. C. Bridgeman, and also a special subcommittee, under the chairmanship of T. G. Delbridge, to cooperate with the Federal Specifications Board on the revision of federal specifications for petroleum products.

Acting as Sectional Committee Z 11 on Nomenclature and Methods of Testing Petroleum Products and Lubricants, functioning under the procedure of the American Standards Association, the following recommendations in connection with American Standards and American Tentative Standards have been made during the year:

Approval of Revision of American Standard:

Method of Test for Distillation of Natural Gasoline (D 216 – 32) (A.S.A. No. Z 11.11 – 1932)

Approval of A.S.T.M. Standards as American Standards:

Method of Test for Carbon Residue of Petroleum Products (Conradson Carbon Residue) (D 189 – 30) (A.S.A. No. Z 11.25 – 1932)

Methods of Testing Gas Oils (Gravity, Distillation, Sulfur, Carbon Residue, Pour Point, Viscosity, Water) (D 158 – 28) (A.S.A. No. Z 11.26 – 1932)

Advancement of American Tentative Standards to American Standards:

Method of Test for Cloud and Pour Points (D 97 – 30) (A.S.A. No. Z 11.5 – 1932)

Method of Test for Melting Point of Petrolatum (D 127 – 30) (A.S.A. No. Z 11.22 – 1932)

Method of Test for the Determination of Autogenous Ignition Temperatures (D 286 – 30) (A.S.A. No. Z 11.23 – 1932)

Method of Test for Flash Point of Volatile Flammable Liquids (D 56 - 21) (A.S.A. No. Z 11.24 - 1932)

Approval of A.S.T.M. Tentative Standards as American Tentative Standards:

Method of Test for Expressible Oil and Moisture in Paraffin Waxes (D 308 - 29 T) (A.S.A. No. Z 11.27 - 1932)

Definitions of Terms Relating to Petroleum (D 288 - 31 T) (A.S.A. No. Z 11.28 - 1932)

Method of Test for Dilution of Crankcase Oils (D 322 - 30 T) (A.S.A. No. Z 11.29 - 1932)

Method of Test for Precipitation Number of Lubricating Oils (D 91 - 30 T) (A.S.A. No. Z 11.30 - 1932)

These recommendations have been approved by the American Standards Association with A.S.A. numbers as indicated.

The organization of the Committee on Nomenclature and Methods of Testing Petroleum Products and Lubricants of the International Standards Association (I.S.A. Technical Committee No. 28) has been completed and plans have been made to hold a meeting of the committee in London in July in connection with the World Petroleum Congress sponsored by The Institution of Petroleum Technologists. The secretariat of the international committee has been assigned to the American Standards Association.

The voting membership of Committee D-2 now consists of 39 producer, 33 consumer and 9 general interest members.

ACTIVITIES OF SUBCOMMITTEES AND TECHNICAL COMMITTEES

Appended hereto is the report of Subcommittee IV on Grease.

At the January meeting of the committee, Technical Committee A on Gasoline recommended for submission to the Society for immediate publication as tentative a method for determining the knock characteristics of motor fuels. Committee D-2 voted affirmatively on this recommendation and after the usual letter ballot the method was submitted to the Society through Committee E-10 on Standards. Committee E-10 met in New York on March 7 and accepted the method for publication as tentative.[1] This Tentative Method of Test for Knock Characteristics of Motor Fuels (D 357 - 33 T)[2] has been given wide distribution. This method, known as the C.F.R. Motor Method, is based on the apparatus and procedure developed by the Cooperative Fuel Research Committee, composed of representatives of the American Petroleum Institute, National Automobile Chamber of Commerce, Society of Automotive Engineers and the U. S. Bureau of Standards who have been studying this problem since 1928.

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[1] In submitting this tentative method to Committee E-10 on Standards, the committee reported the results of the letter ballot vote as follows: 70 members returned their ballots, of whom 39 voted affirmatively, 16 negatively and 15 refrained from voting.

[2] See p. 746.—ED.

A Symposium on Motor Lubricants, arranged under the sponsorship of Technical Committee B on Motor Oils, was held at the New York Regional Meeting of the Society on March 8.

Technical Committee C on Fuel Oils (Including Diesel Fuels) (Lee Schneitter, chairman).—At the June, 1932, meeting of Technical Committee C, consideration was given to a revision of the Commercial Standard on Domestic and Industrial Fuel Oils (CS 12 - 29) and various changes, mainly in form, after ratification by letter ballot, were recommended to the Commercial Standardization Group of the U. S. Bureau of Standards. The revised Commercial Standard (CS 12 - 32) has been accepted and is now available from the Government Printing Office.

At the same meeting a special committee was appointed to cooperate with the Technical Committee on Lubricants and Liquid Fuels of the Federal Specifications Board to undertake a further revision of the commercial standard which would be satisfactory to the producers and consumers of fuel oils and which would meet the needs of government departments for their purchases of fuel oils. This special committee, under the chairmanship of H. F. Tapp, has held two meetings and has distributed various proposals for the comment of the technical committee. These proposals were discussed at a meeting of the technical committee in New York City on January 26, 1933, but no definite recommendations have yet been agreed upon.

Plans are under way for a further revision of the specification to include requirements for diesel fuels with the intention of submitting them to Committee D-2 for consideration as a prospective tentative standard of the Society.

RECOMMENDATIONS AFFECTING STANDARDS

I. Proposed Revision of Standards:

The committee recommends the revision of two standard methods, as indicated below, to become effective immediately. It accordingly asks for the necessary nine-tenths vote at the annual meeting in order that this revision may be submitted to letter ballot of the Society.

Standard Method of Test for Sulfur in Petroleum Oils Heavier than Illuminating Oil (D 129 - 27).[1]—The following minor change in this method is recommended by Subcommittee VII on Sulfur

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 542.

Determination (H. M. Hancock, chairman) as a desirable qualification of the statement on accuracy:

Section 6.—Change to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

> 6. ***For oils having a sulfur content of 0.5 per cent or greater***, duplicate determinations should agree [to] ***within*** ± 2 per cent [on the basis of the sulfur found].

Standard Methods of Test for Viscosity of Petroleum Products and Lubricants (D 88 – 30).[1]—The following revisions in these methods are recommended by Subcommittee V on Viscosity (W. H. Herschel, chairman) in order to include the additional test temperatures of 140 and 180 F. for the Saybolt Furol viscosimeter for testing road and paving materials made at the request of Committee D-4 on Road and Paving Materials:

Section 2 (c).—Add to the tabulation on range and subdivision of thermometers the following requirements covering two new sets of two thermometers, one set graduated in Fahrenheit and the other in Centigrade degrees:

> Range 134–148 F., subdivision in 0.2 F. for tests at 140 F.
> Range 174–188 F., subdivision in 0.2 F. for tests at 180 F.
>
> or
>
> Range 57–65 C., subdivision in 0.1 C. for tests at 60 C.
> Range 79–87 C., subdivision in 0.1 C. for tests at 82.2 C.

Section 3 (b).—Change this section to read as follows by the addition of the italicized words and figures and the omission of the figures in brackets:

> 3. (*b*) With the Saybolt Furol viscosimeter determinations shall be made at 77, ***100***, 122 or [212] ***210*** F. (25, ***37.8***, 50 or [100] ***98.9*** C.). ***In tests of road and paving materials, determinations may also be made at 140 and 180 F. (60 and 82.2 C.).***

Section 4.—Change the last sentence of the first paragraph of Section 4 to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

> In tests at ***140, 180 and*** 210 [and 212] F. (***60, 82.2 and*** 98.9 [and 100] C.) a variation of ±0.2 F. (0.11 C.) is permitted.

Change the first sentence of the second paragraph of Section 4 to read as follows by the addition of the italicized figures and the omission of those in brackets:

> Any construction of bath may be employed provided the bath temperature necessary to maintain thermal equilibrium (while the oil in the oil tube is well stirred by the oil tube thermometer) is within ±0.1 F. (0.06 C.) from the standard temperature of 77 F. (25 C.) or is not in excess of 100.25, 122.35, 130.50, ***141.0, 181.5 or*** 212 [or 214] F. (37.9, 50.2, 54.7, ***60.6, 83.1*** and 100 [101.1] C.) respectively, for the other standard temperatures previously mentioned.

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 550.

The committee also recommends for publication as a tentative revision of one standard method, the changes indicated below.

Standard Method of Test for Cloud and Pour Points (*D 97 – 30*).[1]—The following revisions in this method recommended by Subcommittee XVI on Cloud and Pour Test (J. B. Rather, chairman) was made desirable by the introduction during the past few years of oils containing pour-point depressants.

Section 9.—Change this section to read as follows by the addition of the italicized words and the omission of those in brackets. No change is proposed in the note following this section.

> 9. The cooling bath, g, shall be of a type suitable for obtaining the required temperatures. The size and shape of the bath are optional but a support, suitable for holding the jacket firmly in a vertical position, is essential. [For determination of very low pour points, a smaller insulated cooling bath may be used and the test jar placed directly in it.] *For determination of pour points below 50 F. two or more baths should be at hand.* The required bath temperatures may be maintained by refrigeration if available, otherwise by suitable freezing mixtures.

Section 10.—Change the fifth and sixth paragraphs of Section 10 to read as follows by the addition of the italicized words and the omission of those in brackets:

> [The temperature of the cooling bath, g, shall be adjusted so that it is below the cloud point of the oil by not less than 15 nor more than 30 F. and this temperature shall be maintained throughout the test.] *The temperature of the cooling bath, g, shall be maintained at not lower than 30 F.* The jacket containing the test jar shall be supported firmly in a vertical position in the cooling bath so that not more than 1 in. of the jacket projects out of the cooling medium.
>
> At each test thermometer reading which is a multiple of 2 F., the test jar shall be removed from the jacket, quickly but without disturbing the oil, inspected for cloud, and replaced in the jacket. This complete operation shall require not more than three seconds. [If the oil does not show a cloud when it has been cooled to 15 F., the test jar shall be placed directly in a cooling bath of suitable temperature.] *If the oil does not show a cloud when it has been cooled to 50 F., the test jar shall be placed in a second bath maintained at a temperature not lower than 0 F. If the oil does not show a cloud when it has been cooled to 20 F., the test jar shall be placed in a third bath maintained at a temperature not lower than −30 F.*

Section 11.—Change the sixth and seventh paragraphs of Section 11 to read as follows by the addition of the italicized words and the omission of those in brackets:

> [The temperature of the cooling bath, g, shall be adjusted so that it is below the pour point of the oil by not less than 15 nor more than 30 F. and this temperature shall be maintained throughout the test.] *The temperature of the cooling bath, g, shall be maintained at not lower than 30 F.* The jacket, containing the test jar, shall be supported firmly in a vertical position in the cooling bath so that not more than 1 in. of the jacket projects out of the cooling medium.

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 481.

Beginning at a temperature 20 F. before the expected pour point, at each test thermometer reading which is a multiple of 5 F., the test jar shall be removed from the jacket carefully and shall be tilted just enough to ascertain whether there is a movement of the oil in the test jar. The complete operation of removal and replacement shall require not more than 3 seconds. [If the oil has not ceased to flow when its temperature has reached 15 F., the cold test jar shall be placed directly in a cooling bath of suitable temperature.] *If the oil has not ceased to flow when its temperature has reached 50 F., the test jar shall be placed in the jacket in a second bath maintained at a temperature not lower than 0 F. If the oil has not ceased to flow when its temperature has reached 20 F., the test jar shall be placed in the jacket in a third bath maintained at a temperature not lower than −30 F. For determinations of very low pour points, additional baths should be maintained with successively lower temperature differentials of about 30 F. In each case the test jar shall be transferred when the temperature of the oil reaches a point 50 F. above the temperature of the new bath. At no time shall the cold test jar be placed directly in the cooling medium.* As soon as the oil in the test jar does not flow when the jar is tilted, the test jar shall be held in a horizontal position for exactly 5 seconds, as noted by a stop watch or other accurate timing device, and observed carefully. If the oil shows any movement under these conditions, the test jar shall be immediately replaced in the jacket [if the temperature of the oil is above 15 F., or directly in the cooling bath if the temperature is below 15 F.,] and a test for flow repeated at the next temperature 5 F. lower.

II. Revision of Tentative Standard:

The committee recommends the revision of one tentative method as indicated:

Tentative Method of Test for Penetration of Greases and Petrolatum (D 217 - 27 T).[1]—The following minor change in this method is recommended by Subcommittee IV on Grease (G. H. Harnden, chairman) to eliminate the discrepancy in results due to varying the size of the container:

Section 14.—Omit the next to the last sentence in the procedure for worked consistency which reads as follows:

> If desired, the grease may be transferred carefully to another container before bringing to 77 F. (25 C.) and testing.

III. Advancement of Tentative Standards to Standard:

The committee recommends the submission of the following tentative methods to letter ballot of the Society for adoption as standards:

Tentative Method of Test for Dilution of Crankcase Oils (D 322 - 30 T),[2] without revision, as proposed by Subcommittee XXV on Crankcase Dilution (T. H. Rogers, chairman).

Tentative Method of Test for Distillation of Crude Petroleum (D 285 - 30 T),[2] without revision, as proposed by Subcommittee XXI on Crude Petroleum (A. J. Kraemer, chairman).

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 27, Part I, p. 930 (1927); also 1932 Book of A.S.T.M. Tentative Standards, p. 586.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, pp. 1112, 1115 (1930); also 1932 Book of A.S.T.M. Tentative Standards, pp. 560, 563.

Tentative Method of Test for Gravity of Petroleum and Petroleum Products by Means of the Hydrometer (D 287 – 32 T),[1] revised in accordance with the recommendations of Subcommittee II on Specific Gravity (H. T. Bennett, chairman) as follows:

Section 7.—Change the last sentence of the first paragraph to read as follows by the addition of the italicized words and the omission of those in brackets:

> If the [sample] ***product*** to be tested is easily volatile [both] the ***sample, thermometer***, hydrometer, and hydrometer cylinder shall be cooled [before use] to a ***sufficiently low*** temperature [below that of the sample] ***before testing to insure that no volatile fractions are lost during the necessary handling.***

Section 9.—Change the first sentence of the second paragraph to read as follows by the addition of the italicized words and figures:

> Separate laboratories using different hydrometers and thermometers should obtain duplicate results agreeing within 0.5° A.P.I. or the equivalent thereof in units of specific gravity at the particular gravity being determined, ***provided the observed temperatures do not vary more than plus or minus 18 F. (plus or minus 10 C.).***

Tentative Method of Test for Precipitation Number of Lubricating Oils (D 91 – 30 T),[2] without revision, as proposed by Subcommittee IX on Precipitation (L. W. Parsons, chairman).

Tentative Methods of Sampling Petroleum and Petroleum Products (D 270 – 30 T)[3] revised in accordance with the recommendation of Subcommittee XV on Sampling and Gaging (A. E. Flowers, chairman) as follows:

Section 5.—Change Paragraphs (*a*) and (*b*) of Section 5 to read as follows by the addition of the italicized words and the omission of those in brackets:

> 5. For sampling [purposes], material may be classified as follows:
>
> (*a*) Liquid materials, such as light crude oils, ***naphthas***, gas oils, lubricating oils and [naphthas] ***light fuel oils.***
>
> (*b*) Semi liquid and highly viscous materials, such as cylinder stocks and heavy ***crude or*** fuel oils.

Section 55 (*b*) (*Note*).—Change the drawing in Fig. 4 so that the attachment of the leg pieces will show no projections beyond the outline of the body diameter of 1¼ in.

Section 56.—Change the third sentence in the Note to read as follows by the addition of the italicized words and the omission of those in brackets:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 757 (1932); also 1932 Book of A.S.T.M. Tentative Standards, p. 570.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, pp. 1130, 1090 (1930); also 1932 Book of A.S.T.M. Tentative Standards, pp. 592, 596.

[However, if] Samples [are] placed in glass bottles [they] shall be kept in the dark [until portions are removed for testing for] *if subsequent testing is to include* color and sludge forming characteristics *or neutralization values* [as light produces changes in these properties].

Section 59.—In the Note following Paragraph (*a*) add the following sentence after the fourth sentence of the Note:

Bottles or containers shall be so handled that the operator's fingers never touch the lip, and a portion of the sample shall be poured over the lip and thrown away before pouring the sample into the testing apparatus.

Change the last sentence of Paragraph (*e*) to read as follows by the addition of the italicized words:

To sample a shipment of cans of less capacity than 5 gal., one or more cans shall be selected at random from the shipment *in accordance with Section 37*, using the entire *contents of the* can or cans as the sample.

Section 60.—Add the following note at the end of this section:

NOTE.—Instead of empty sample containers the operator may carry along containers filled with clean tested oil which may be poured into the top of the apparatus to compensate for the quantity removed.

Section 63 (*e*).—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

(*e*) If no visible differences appear in the borings they may be combined, preserved, examined and tested as a single sample but this shall be done only *by the laboratory tester* after the three sets of borings have been delivered [to the laboratory and by the laboratory tester].

IV. Advancement of Tentative Revisions of Standard Methods to Standard:

The committee recommends the submission of the following tentative revisions of standard methods to letter ballot of the Society for adoption as standard and incorporation in the respective standard methods:

Revision of Standard Method of Test for Cloud and Pour Points (*D 97 - 30*), as proposed in the report of the committee for 1932.[1]

Revision of Standard Method of Test for Flash and Fire Points by Means of Open Cup (*D 92 - 24*), as proposed in the report of the committee for 1932.[2]

Revision of Standard Methods of Test for Viscosity of Petroleum Products and Lubricants (*D 88 - 30*), as proposed in the reports of the committee for 1931[3] and 1932.[4]

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 394 (1932).

[2] *Ibid.*, p. 395.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 463 (1931).

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 396 (1932).

V. Tentative Standards Continued as Tentative:

Four methods of test under the jurisdiction of the committee have been tentative for a period of three years or longer without revision as follows:

Tentative Method of Test for Color of Refined Petroleum Oil by Means of Saybolt Chromometer (D 156 – 23 T);

Tentative Method of Test for Neutralization Number of Petroleum Products and Lubricants (D 188 – 27 T);

Tentative Method of Test for Expressible Oil and Moisture in Paraffin Waxes (D 308 – 29 T); and

Tentative Method of Test for Sulfur in Motor Fuels, Naphthas and Illuminating Oils (Lamp Method) (D 90 – 30 T).

The third of these methods is a highly empirical one and has not had a sufficiently long period of trial to justify its advancement because of its relatively infrequent use. Further study of the other methods is being made which may lead to their modification. It is accordingly recommended that these methods be continued as tentative.

The recommendations appearing in this report have been submitted to letter ballot of the committee with the following results:

Items	Affirmative	Negative	Not Voting
I. PROPOSED REVISION OF STANDARDS			
Test for Sulfur in Petroleum Oils Heavier than Illuminating Oil (D 129 – 27), immediate adoption	52	0	1
Test for Viscosity of Petroleum Products and Lubricants (D 88 – 30), immediate adoption	46	0	1
Test for Cloud and Pour Points (D 97 – 30)	39	5	3
II. REVISION OF TENTATIVE STANDARD			
Test for Penetration of Greases and Petrolatum (D 217 – 27 T)	49	0	4
III. ADVANCEMENT OF TENTATIVE STANDARDS TO STANDARD			
Test for Dilution of Crankcase Oils (D 322 – 30 T)	47	2	4
Test for Distillation of Crude Petroleum (D 285 – 30 T)	44	2	7
Test for Gravity of Petroleum and Petroleum Products (D 287 – 32 T), as revised	51	1	1
Test for Precipitation Number of Lubricating Oils (D 91 – 30 T)	50	1	2
Methods of Sampling Petroleum and Petroleum Products (D 270 – 30 T), as revised	51	0	2
IV. ADVANCEMENT OF TENTATIVE REVISION OF STANDARDS TO STANDARD			
Test for Cloud and Pour Points (D 97 – 30)	52	1	0
Test for Flash and Fire Points by Means of Open Cup (D 92 – 24)	52	0	1
Test for Viscosity of Petroleum Products and Lubricants (D 88 – 30)	53	0	0

This report has been submitted to letter ballot of the committee, which consists of 81 members; 53 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

T. A. BOYD,
Chairman.

R. P. ANDERSON,
Secretary.

EDITORIAL NOTE

The revision proposed for immediate adoption in the Standard Method of Test for Sulfur in Petroleum Oils Heavier than Illuminating Oil was unanimously approved at the annual meeting and was subsequently adopted by letter ballot of the Society on September 1, 1933. The method in its revised form appears in the 1933 Book of A.S.T.M. Standards, Part II, page 872. Revisions in the Standard Methods of Test for Viscosity of Petroleum Products and Lubricants, proposed on the floor of the annual meeting for immediate adoption, see Summary of Proceedings, page 19, were unanimously approved at the annual meeting and subsequently adopted by letter ballot of the Society on September 1, 1933 The methods in their revised form appear in the 1933 Book of A.S.T.M. Standards, Part II, page 880. Revisions in the Standard Method of Test for Cloud and Pour Points, proposed on the floor of the annual meeting, see Summary of Proceedings, page 20, were accepted for publication as tentative and appear on page 1041.

The proposed revision of the Tentative Method of Test for Penetration of Greases and Petrolatum was accepted. The method as revised appears on page 756.

The Tentative Methods of Test for Dilution of Crankcase Oils, Test for Distillation of Crude Petroleum, Test for Precipitation Number of Lubricating Oils, Test for Gravity of Petroleum and Petroleum Products by Means of the Hydrometer, and Methods of Sampling Petroleum and Petroleum Products, the latter two as revised, were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1933. The methods appear in the 1933 Book of A.S.T.M. Standards, Part II, pages 768, 771, 842, 819 and 846, respectively.

The tentative revisions of the Standard Methods of Test for Cloud and Pour Points, Test for Flash and Fire Points by Means of Open Cup and Test for Viscosity of Petroleum Products and Lubricants were unanimously approved at the annual meeting and subsequently adopted by letter ballot of the Society on September 1, 1933. The methods in their revised form appear in the 1933 Book of A.S.T.M. Standards, Part II, pages 761, 800 and 880, respectively.

REPORT OF SUBCOMMITTEE IV ON GREASE

The penetration of some commercial greases, when determined by the Tentative Method of Test for Penetration of Greases and Petrolatum (D 217 – 27 T)[1] may be as low as 12 or 15 and a possible improvement in the accuracy of the test for these greases has been studied. It has been found entirely feasible to weight the shaft of the penetrometer to obtain higher readings. The weights are conveniently made by casting lead collars to fit in the top of the standard cone, thus providing a convenient arrangement which keeps the center of gravity over the point of the needle. Added weights of 200 and 300 g. have been used and representative data obtained were as follows:

Added weight, g	0	200	300
Total weight of plunger, g	150	350	450
		Penetration	
Sample A, average of 6 tests	23.7	44.7	54.8
Sample A, average deviation, per cent	2.8	3.0	3.3
Sample B, average of 6 tests	20.2	38.3	44.7
Sample B, average deviation, per cent	4.1	2.6	2.5

These data indicate that there is little advantage, from the standpoint of accuracy, in using a heavier shaft. Indications were obtained with greases of this type that lack of homogeneity, due to the fact that the tests are made on the unworked sample, may be a very important factor. Another observation was that irregularities may arise from dulling of the point of the cone, a result which is not experienced appreciably with softer greases. These results are reported merely for information. It is not recommended that any change for hard greases be made in the Tentative Method D 217 – 27 T.

To eliminate the discrepancy in results due to varying the size of the container, the subcommittee proposes the deletion of the last sentence in Section 14 of the Tentative Method D 217, as recommended previously in the main report.

A paper describing "A Procedure for Measuring Bleeding of Cup Greases," developed by Winslow H. Herschel is appended hereto.

Respectfully submitted on behalf of the subcommittee,

G. H. Harnden,
Chairman.

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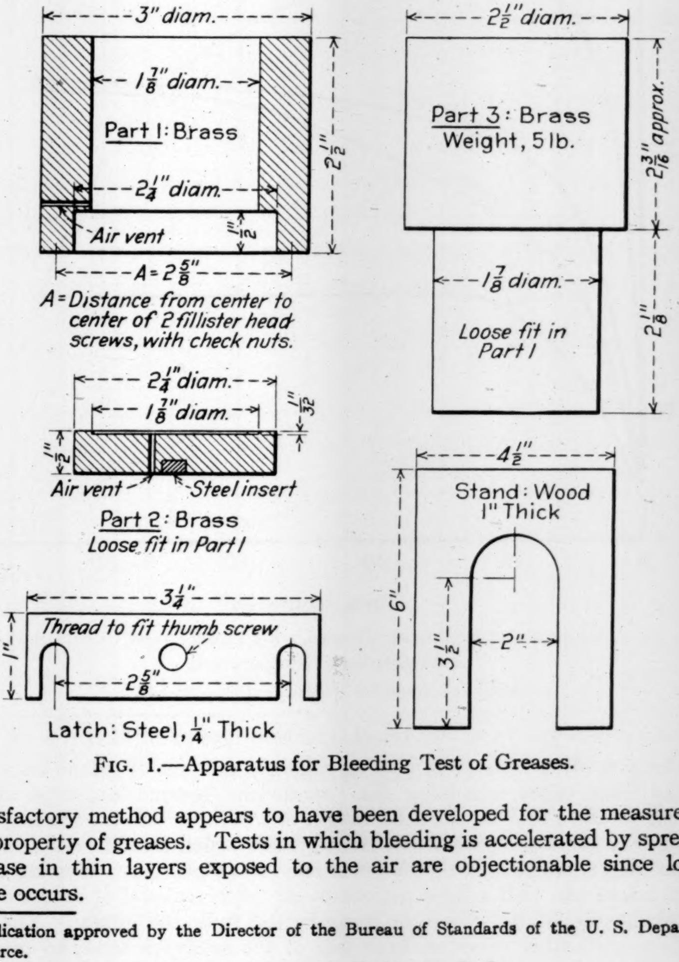
[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 27, Part I, p. 930 (1927); also 1932 Book of A.S.T.M. Tentative Standards, p. 586.

APPENDIX

A PROCEDURE FOR MEASURING BLEEDING OF CUP GREASES[1]

By Winslow H. Herschel[2]

Separation of oil from greases, called "bleeding," frequently occurs both in storage and in service. It is known that the extent of separation varies with different greases and that it depends upon the conditions in storage and service.



3" diam.
1 7/8" diam.
Part 1: Brass
2 1/2"
2 1/4" diam.
Air vent
1/2"
A = 2 5/8"
A = Distance from center to center of 2 fillister head screws, with check nuts.
2 1/4" diam.
1 7/8" diam.
1/32"
1/2"
Air vent
Steel insert
Part 2: Brass
Loose fit in Part 1
3 1/4"
Thread to fit thumb screw
1"
2 5/8"
Latch: Steel, 1/4" Thick
2 1/2" diam.
Part 3: Brass
Weight, 5 lb.
2 3/16" approx.
1 7/8 diam.
Loose fit in Part 1
2 1/8"
4 1/2"
Stand: Wood
1" Thick
6"
3 1/2"
2"

FIG. 1.—Apparatus for Bleeding Test of Greases.

No satisfactory method appears to have been developed for the measurement of this property of greases. Tests in which bleeding is accelerated by spreading the grease in thin layers exposed to the air are objectionable since loss of moisture occurs.

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[1] Publication approved by the Director of the Bureau of Standards of the U. S. Department of Commerce.

[2] Associate Physicist, U. S. Bureau of Standards, Washington, D. C.

In the course of an investigation being conducted at the U. S. Bureau of Standards on the significant properties of greases, a general type of method has been developed for the measurement of bleeding which appears to have considerable significance. The method is sufficiently flexible to permit an investigation of the effect on bleeding of variations in pressure, temperature and duration of test. A general description of the apparatus and method is given here in the hope that it may stimulate further research on the problem.

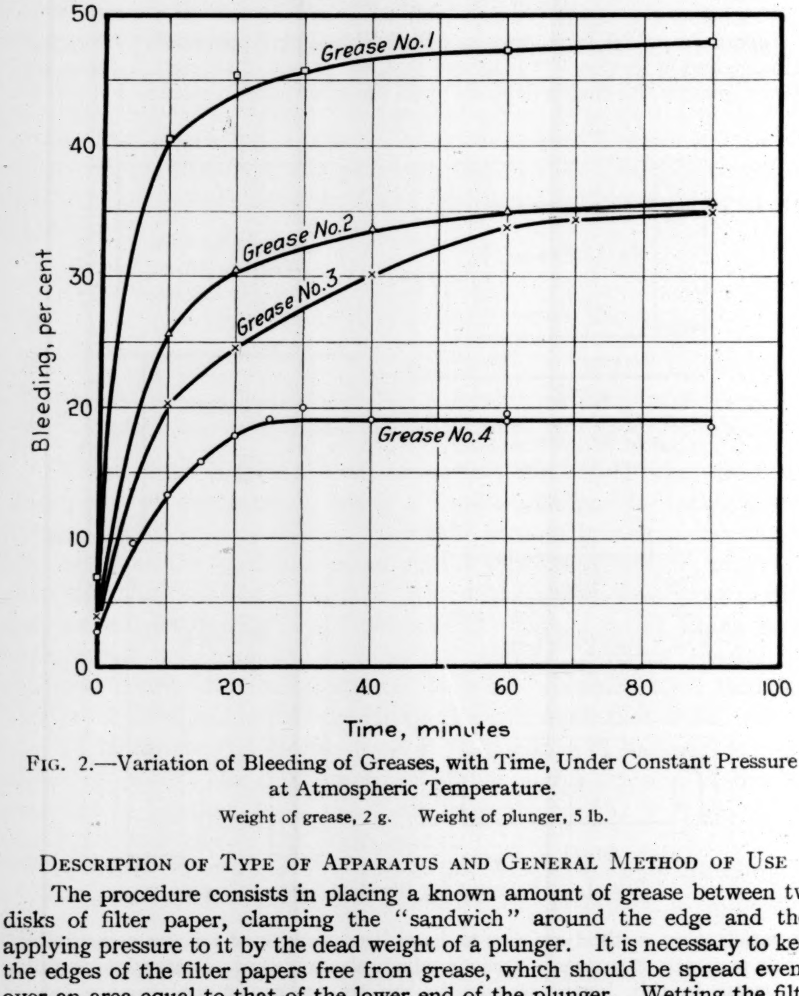

FIG. 2.—Variation of Bleeding of Greases, with Time, Under Constant Pressure at Atmospheric Temperature.

Weight of grease, 2 g. Weight of plunger, 5 lb.

DESCRIPTION OF TYPE OF APPARATUS AND GENERAL METHOD OF USE

The procedure consists in placing a known amount of grease between two disks of filter paper, clamping the "sandwich" around the edge and then applying pressure to it by the dead weight of a plunger. It is necessary to keep the edges of the filter papers free from grease, which should be spread evenly over an area equal to that of the lower end of the plunger. Wetting the filter papers before use with a light petroleum oil (with removal of excess oil) helps to minimize capillarity effects in removing oil from the grease. The placing of a disk of blotting paper on each side of the sandwich tends to prevent reabsorption of oil by the sandwich after the pressure is removed. Ordinarily, no grease leaks out of the sandwich and all the oil is absorbed by the blotting paper so that the tester is dry and clean at the end of a test. The difference in weight of the sandwich before and after application of pressure gives directly

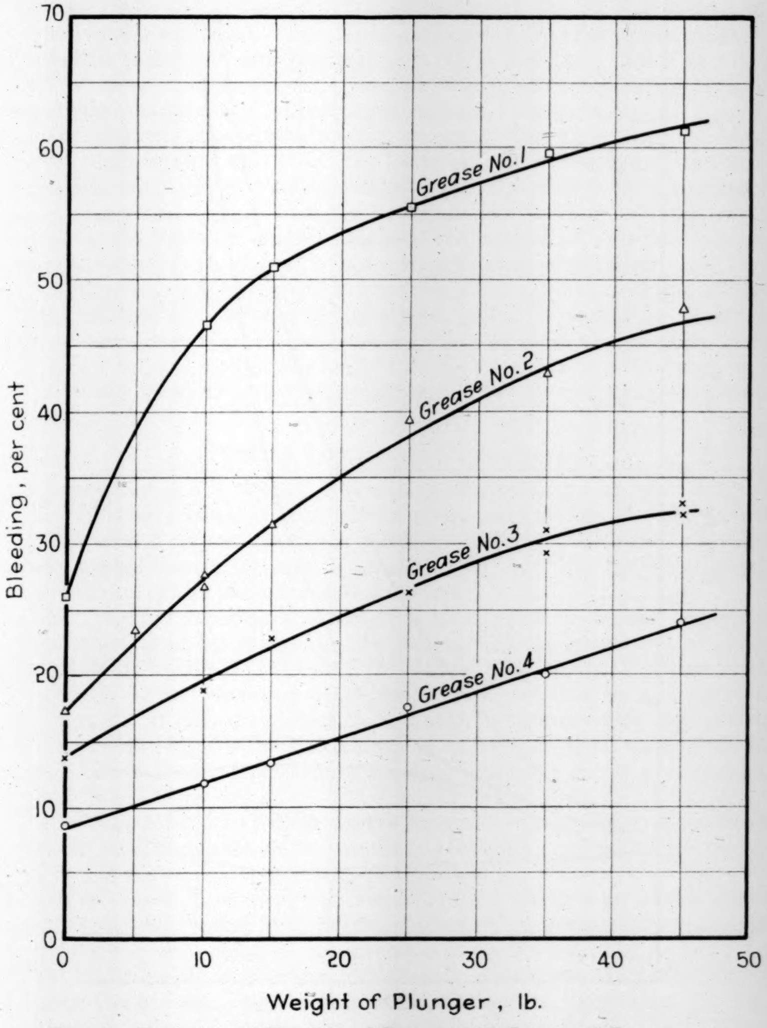

FIG. 3.—Variation of Bleeding of Greases with Increased Pressure at Atmospheric Temperature.

Weight of grease, 2 g. Time, 5 minutes.

the amount of bleeding. If the filter papers are wet before use, the decrease in weight of the sandwich should approximately equal the increase in weight of the two disks of blotting paper.

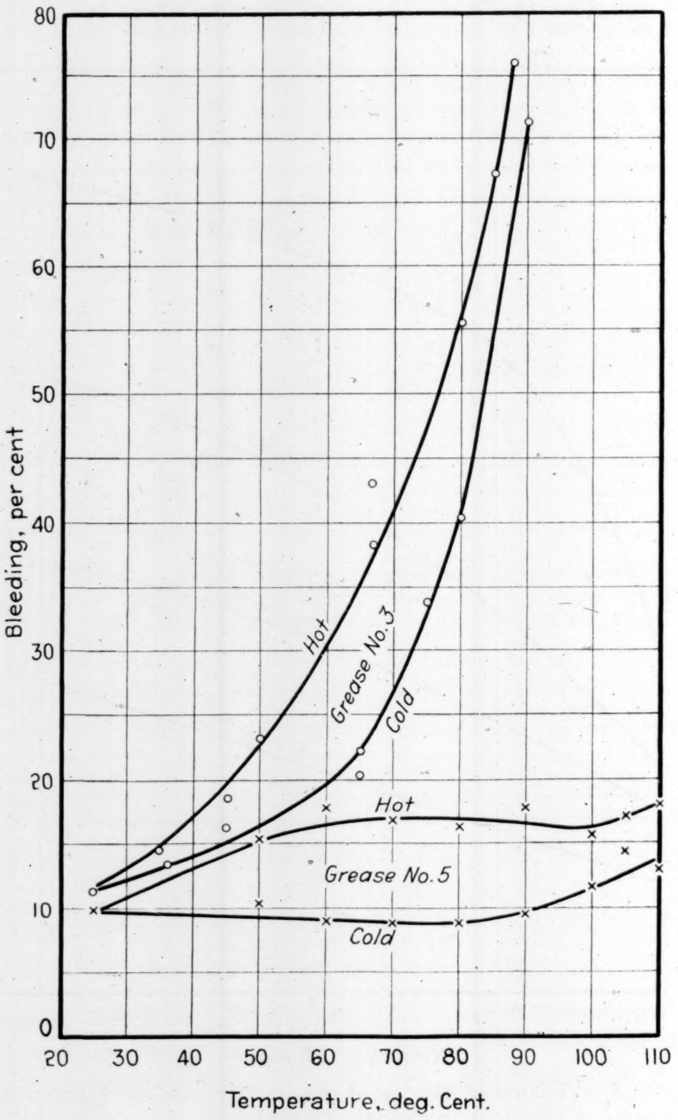

FIG. 4.—Effect of Variations in Temperature on Bleeding of Greases.

Weight of grease, 2 g. Weight of plunger, 5 lb. Time, 5 minutes.

A detailed drawing of the general type of apparatus is shown in Fig. 1. In making a determination, part 1 is turned upside down and a blotter, the sandwich and the second blotter are inserted in succession. Part 2 is placed in position, with the recessed side down, the latch is slipped into place and the thumb screw is tightened. Finally the apparatus is placed, right side up, on the wooden stand and the plunger (part 3) is inserted. After the desired length of time, measured with a stop watch, the apparatus is quickly disassembled, and the sandwich and wet blotters are weighed.

With the type of sandwich used, it was found that there was some bleeding after the sandwich was clamped in the tester but before insertion of the plunger, and the apparatus of Fig. 1 was therefore designed so that it could be assembled very rapidly (6 seconds). In order to reduce the bleeding before application of pressure, the sandwich might be made of one cupped and one flat filter paper, the cupped paper being shaped to the form of a shallow cylinder.

No difference was observed between the bleeding of worked and unworked greases, but use of a worked grease avoids errors in sampling. Tests were made on ten greases of various consistencies, at room temperature without temperature control, and it was found that for no grease was the range, in five tests, between maximum and minimum values of the percentage of bleeding, in excess of 1.5.

TYPE OF INFORMATION OBTAINABLE

Illustrations of the type of information obtainable are shown in Figs. 2, 3 and 4. It is seen (Fig. 2) that with a given pressure the bleeding increases with time until a constant value is reached. With a given time interval, the bleeding increases with increase in pressure (Fig. 3). The extent of bleeding before insertion of the plunger may also be seen.

The effect of temperature on extent of bleeding at the higher temperatures may be complicated by changes in the structure of the grease and by changes in the moisture content, although it is believed that in the proposed method the grease is better protected from loss of moisture than in any previously described test. It should be noted that at such temperatures the loss in weight of the sandwich may not be due mainly to separation of oil since, with some greases, there is no apparent separation even when the grease has completely liquefied.

In tests marked "hot" (Fig. 4), the sandwich was placed in a watch glass and heated, with the tester, in the oven for 15 minutes. The sandwich was then placed in the tester, under pressure, in the oven for 5 minutes longer. With tests marked "cold," the sandwich was left in the watch glass in the oven for 20 minutes, and was cooled to room temperature before the pressure was applied. A comparison of any point on a cold-test curve with the point at room temperature for the grease in question, indicates the permanent effect upon bleeding of heating the grease under the conditions described. The values plotted in Fig. 4 were calculated from the loss in weight of the sandwich. The difference between these values and corresponding values (not shown) calculated from the increase in weight of the blotters is a measure of the oil which escapes from the sandwich into the watch glass before pressure is applied. The two greases of Fig. 4 were of approximately the same consistency. As a general rule, the softer a grease the higher the bleeding at room temperature.

REPORT OF COMMITTEE D-4

ON

ROAD AND PAVING MATERIALS

Since the 1932 annual meeting Committee D-4 on Road and Paving Materials has presented to the Society, through Committee E-10 on Standards, revisions of the Tentative Methods of Test for Ductility of Bituminous Materials (D 113 - 26 T) and Test for Residue of Specified Penetration (D 243 - 28 T). The revised methods were accepted for publication as tentative[1] by Committee E-10 at a meeting held on August 11, 1932, and appear in their latest form in the 1932 *Proceedings*.[2]

RECOMMENDATIONS AFFECTING STANDARDS

Proposed Tentative Specifications for Concrete for Pavements.—The committee recommends for publication as tentative the proposed Specifications for Concrete for Pavements appended hereto.[3] These specifications represent the result of some two years of work on the part of Subcommittee C-5 on Portland-Cement Concrete for Pavements and Bases (R. W. Crum, chairman), which has had the benefit of detailed criticism and advice from all interested members of the main committee. The work on this subject was undertaken because it was felt that the existence of specifications for concrete for pavements would have great influence in extending the knowledge and use of the best practice available.

Standard Method of Test for Abrasion of Rock (D 2 - 26).[4]—In order to bring this method into harmony with the Tentative Method of Test for Abrasion of Gravel (D 289 - 28 T) and to have it conform to what has become customary practice in the use of standard sieves, the committee recommends that this method be revised as follows:

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[1] In submitting these revised methods to Committee E-10 on Standards, the committee reported the following results of the letter ballot vote of a total of 63 ballots returned from a committee membership of 88: Tentative Method of Test for Ductility of Bituminous Materials (D 113 - 26 T), 55 affirmative and 1 negative; Tentative Method of Test for Residue Penetration (D 243 - 28 T), 52 affirmative and 1 negative.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, pp. 781 and 784, respectively.

[3] See p. 764.—ED.

[4] 1930 Book of A.S.T.M. Standards, Part II, p. 609.

Section 3.—Change the fourth sentence from its present form: namely,

> Only the percentage of material worn off which will pass through a 0.16-cm. ($\frac{1}{16}$-in.) mesh sieve shall be considered in determining the amount of wear.

to read as follows:

> Only the percentage of material worn off which will pass through a No. 12 sieve conforming to the requirements of the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials shall be considered in determining the amount of wear.

For the reasons mentioned above and because it is felt that the proposed revision will not appreciably modify the results of tests, it is recommended that the proposed revision be incorporated in the present standard without publication as a tentative revision. The committee accordingly asks for the necessary nine tenths vote at the annual meeting in order that this revision may be submitted to letter ballot of the Society for immediate adoption.

Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds (D 6 – 30).[1]—In order more clearly to define the temperature requirements for this method, the committee recommends that it be revised as follows:

Section 6.—Change the fourth sentence to read as follows by the addition of the italicized words and figures:

> The temperature shall be maintained at 163 C. *plus or minus 1 C.* (325 F. *plus or minus 1.8 F.*) for 5 hours after the sample has been introduced and the oven has again reached that temperature.

Section 7.—Change the first sentence to read as follows by the addition of the italicized words:

> During the 5-hour period the temperature shall not vary more than *plus or minus* 1 C. (*plus or minus 1.8 F.*).

As the proposed revision is merely a more definite statement of existing requirements of the method, it is recommended that it be incorporated in the present standard without publication as a tentative revision. The committee accordingly asks for the necessary nine tenths vote at the annual meeting in order that this revision may be submitted to letter ballot of the Society for immediate adoption.

Standard Definitions of Terms Relating to Materials for Roads and Pavements (D 8 – 18).[2]—The following revised definition of the term coal tar appearing in the Standard Definitions D 8 was approved by the committee at the annual meeting and recommended for immediate adoption:

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 638.

[2] *Ibid.*, p. 673.

Coal Tar.—Tar produced by the destructive distillation of bituminous coal.

The above definition was proposed by Committee E-8 on Nomenclature and Definitions in view of a conflict between the standard definition for coal tar adopted by Committee D-7 on Timber and and that adopted by Committee D-4. The proposed definition has also been accepted by Committee D-7.

Tentative Specifications for Calcium Chloride for Dust Prevention (D 98 - 30 T)[1].—In order to broaden its scope and to make it conform more closely to available commercial products, the committee recommends that these specifications be revised as follows and continued as tentative:

Title.—Change the title by omission of the words "for Dust Prevention."

Section 1.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

> 1. These specifications cover calcium chloride to be [applied to the surface of highways as a dust preventive] *used for road purposes, acceleration of concrete and curing of concrete.*

Section 2.—Change the first sentence to read as follows by the omission of the words in brackets:

> The calcium chloride shall be in the form of [loose dry lumps or] flakes and when tested by means of laboratory screens and sieves shall conform to the following requirements:

Section 3.—Change the requirement for percentage of calcium chloride to read as follows by the addition of the italicized figures and the omission of those in brackets:

$CaCl_2$ (anhydrous)..........................not less than [73] *77* per cent

Tentative Methods of Testing Bituminous Emulsions (D 244 - 28 T).[2]—In order to meet criticisms received and to clarify the meaning of certain requirements the committee recommends that these methods be revised as follows and continued as tentative:

Section 4.—Change the third sentence of the first paragraph from its present form: namely,

> A thermometer 0 to 400 C. shall be provided conforming to the requirements for the thermometer specified in Section 6 of the Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (A.S.T.M. Designation: D 20) of the American Society for Testing Materials.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 1145 (1930); also 1932 Book of A.S.T.M. Tentative Standards, p. 646.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 952 (1928); also 1932 Book of A.S.T.M. Tentative Standards, p. 691.

to read as follows:

> A thermometer 0 to 300 C. (30 to 580 F.) shall be provided conforming to the requirements for the thermometer specified in Section 6 (*a*) of the Standard Method of Test for Distillation of Gasoline, Naphtha, Kerosine and Similar Petroleum Products (A.S.T.M. Designation: D 86) of the American Society for Testing Materials.

Add a note to the fifth paragraph of Section 4 as follows:

> The distillation should be completed in not less than 1 hour and in not more than 1¼ hours (see Note).
>
> NOTE.—While the period of time for distillation should be conveniently short, the maximum suggested is not mandatory, so if a longer period of time is required for the distillation of any emulsion this shall not be considered as cause for the rejection of the material or as a departure from the intent of the method.

The recommendations appearing in this report have been submitted to letter ballot of the committee with the following results:

Items	Affirmative	Negative	Not Voting
I. PROPOSED TENTATIVE STANDARD			
Specifications for Concrete for Pavements	45	1	15
II. PROPOSED REVISION OF STANDARDS			
Test for Abrasion of Rock (D 2 - 26), immediate adoption	49	0	12
Test for Loss on Heating of Oil and Asphaltic Compounds (D 6 - 30), immediate adoption	49	1	11
Definitons of Terms Relating to Materials for Roads and Pavements (D 8-18), immediate adoption	61	1	0
III. REVISION OF TENTATIVE STANDARDS			
Specifications for Calcium Chloride for Dust Prevention (D 98 - 30 T)	49	0	12
Methods of Testing Bituminous Emulsions (D 244 - 28 T)	47	0	14

This report has been submitted to letter ballot of the committee, which consists of 87 members; 61 members returned their ballots, of whom 55 have voted affirmatively and none negatively.

Respectfully submitted on behalf of the committee,

H. F. CLEMMER,
Chairman.

PRÉVOST HUBBARD,
Secretary.

EDITORIAL NOTE

The proposed Tentative Specifications for Concrete for Pavements were accepted for publication as tentative and appear on page 764.

Revisions proposed for immediate adoption in the Standard Methods of Test for Abrasion of Rock and for Loss on Heating of Oil and Asphaltic Compounds were approved at the annual meeting by a unanimous vote and were subsequently adopted by letter ballot of the Society on September 1, 1933. The methods in their revised form appear in the 1933 Book of A.S.T.M. Standards, Part II, pages 944 and 962, respectively.

A revision of the definition for coal tar, appearing in the Standard Definitions of Terms Relating to Materials for Roads and Pavements, presented on the floor of the annual meeting for immediate adoption, see Summary of Proceedings, page 18, was approved at the annual meeting by a unanimous vote and was subsequently adopted by letter ballot of the Society on September 1, 1933. The definition in its revised form appears in the 1933 Book of A.S.T.M. Standards, Part II, page 1008.

The proposed revisions of the Tentative Specifications for Calcium Chloride for Dust Prevention and of the Tentative Methods of Testing Bituminous Emulsions were accepted. The specifications and methods in their revised form appear on pages 762 and 774, respectively.

REPORT OF COMMITTEE D-5

ON

COAL AND COKE

Committee D-5 on Coal and Coke did not hold its usual spring meeting during the year. A meeting will be held during the annual meeting of the Society. The Tentative Definition of the Term Coke (D 121 – 30 T) and the Tentative Method of Sampling Coke for Analysis (D 346 – 32 T) are being continued as tentative in view of possible modification. The committee is recommending for advancement to standard the Tentative Method of Sampling Coal by Ball-Mill Method (D 271 – 32 T).

A new subcommittee, designated as Subcommittee XII on Sampling Coal at Coal Cleaning Plants, under the chairmanship of T. W. Guy, is being organized to investigate sampling methods for use at coal cleaning plants. Sampling at such plants includes sampling for analysis and sampling for float-and-sink methods of determining extraneous impurities in coal. Mr. Guy has already assembled considerable data on this problem in connection with his chairmanship of the Subcommittee on Methods of Sampling and Testing Bituminous Coal, of the Sectional Committee on Specifications for Clean Bituminous Coal functioning under the American Standards Association.

ACTIVITIES OF SUBCOMMITTEES

Subcommittee I on Methods of Testing (W. A. Selvig, chairman).—Experimental work on the agglutinating value test, conducted during the past two years at the Pittsburgh Experiment Station of the U. S. Bureau of Mines, has been completed and summarized in a paper entitled "Agglutinating Value Test for Coal," by W. A. Selvig, B. B. Beattie and J. B. Clelland, which will be presented at this annual meeting of the Society.[1]

In cooperation with the Standard Pyrometric Cone Co. a batch of 150 lb. of a cone powder was prepared for checking the operation of the gas furnace used in determining fusibility of coal ash. This cone powder contains a relatively high percentage of iron oxide and so is especially well adapted to check the atmosphere of the furnace. Samples were submitted to various laboratories equipped with the standard gas furnace, and fusion tests were made in the same manner as specified for coal ash. Table I shows the results of these fusion tests. Good check results were obtained by the cooperating laboratories in the determination of the "softening temperature." Laboratories interested is using this cone powder for checking purposes can purchase it from the Standard Pyrometric Cone Co., Columbus, Ohio. The cone powder should be ground in the laboratory to pass through a 74-micron (No. 200) sieve and should be ignited to constant weight at a temperature of from 800 to 900C. This ignition is necessary to drive off water of hydration and carbonates which, unless removed, cause trouble in observing the softening temperature due to swelling of the cone during fusion.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part II, p. 741 (1933).

TABLE I.—COOPERATIVE FUSION TESTS ON PYROMETRIC CONE POWDER.

Laboratory	Fusibility, deg. Fahr.						
	Individual Determinations				Average		
	Initial Deformation Temperature	Softening Temperature	Maximum Difference	Fluid Temperature	Initial Deformation Temperature	Softening Temperature	Fluid Temperature
No. 1	2057 2048 2075	2152 2152 2165	13	2498 2480 2541	2060	2160	2510
No. 2	2065 2090	2170 2180	10	2425 2415	2080	2180	2420
No. 3	2020 2030 1990 2020	2130 2140 2140 2150	20	2330 2330 2350 2340	2020	2140	2340
No. 4	2025 1995	2140 2150	10	[a] 2400	2010	2150	2400
No. 5	2054 2054	2186 2157	29	2287 2296	2050	2170	2290
No. 6	2010 2050	2110 2110	0	2440 2440	2030	2110	2440
Average of all laboratories	....	....	....	....	2040	2150	2400

[a] Not determined.

Subcommittee II on Nomenclature and Definitions. (H. C. Porter, chairman).—This subcommittee is cooperating with Committee E-8 on Nomenclature and Definitions in the formulation of definitions of the terms "net calorific value," "gross calorific value" and "coke."

Subcommittee VII on Pulverizing Characteristics of Coal (John Van Brunt, chairman).—A paper by R. A. Sherman, C. E. Irion and E. J. Rogers on "A Study of Adsorption as a Method for the Determination of the Surface of Pulverized Coal" which covers work done at the Battelle Memorial Institute on the use of adsorption of dyes for determining increased surface produced by grinding coal, is to be presented at this annual meeting of the Society.[1] Considerable work has been done on various laboratory grindability methods under the direction of R. E. Gilmore of the Fuel Research Laboratories of the Mines Department of Canada at Ottawa. The results of this work and a new method of test will be published shortly as a mimeographed memorandum report of the Canadian Department of Mines.

Subcommittee XI on Coal Friability (R. E. Gilmore, chairman).—Progress has been made during the past year in various laboratories on methods of testing the resistance of coal to handling. Two methods are being used, namely, a drop test, similar to the well known shatter test for coke; and various forms of tumbler tests using either laboratory jars, such as used in preparing coal samples, or large drums such as are used for testing coke and paving brick for abrasion.

RECOMMENDATIONS AFFECTING STANDARDS

As no constructive criticism of the Tentative Method of Sampling Coal by Ball-Mill Method (D 271 - 32 T)[2] has been received the committee recommends that the method be referred to letter ballot of the Society for adoption as standard and included as an alternate procedure of laboratory sampling of coal in the Standard Methods of Laboratory Sampling and Analysis of Coal and Coke (D 271 - 30). This recommendation has been referred to letter ballot of the committee, which consists of 39 members; 34 members returned their ballots, of whom 32 have voted affirmatively, 0 negatively and 2 marked their ballots not voting.

The committee recommends that the Tentative Definition of the Term Coke (D 121 - 30 T) and the Tentative Method of Sampling Coke for Analysis (D 346 - 32 T) be continued as tentative in view of possible modifications now under consideration.

This report has been submitted to letter ballot of the committee, which consists of 39 members; 34 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

A. C. FIELDNER,
Chairman.

H. C. PORTER,
Vice-Chairman.

W. A. SELVIG,
Secretary.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part II, p. 729 (1933).

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 794 (1932); also 1932 Book of A.S.T.M Tentative Standards, p. 710.

EDITORIAL NOTE

The tentative revision of the Standard Methods of Laboratory Sampling and Analysis of Coal and Coke comprising an alternate procedure of laboratory sampling of coal was approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1933. The methods in their revised form appear in the 1933 Book of A.S.T.M. Standards, Part II, page 269.

Recommendations to Committee E-10 on Standards.—A revision of the Tentative Method of Sampling Coke for Analysis was approved by the committee subsequent to the annual meeting and was accepted on August 16, 1933, by Committee E-10 on Standards. The method in its revised form appears on page 715.

A proposed revision of the Standard Method of Test for Size of Anthracite was also presented to Committee E-10 and accepted for publication as tentative on September 2, 1933. The tentative revision appears on page 1049.

REPORT OF SECTIONAL COMMITTEE
ON
CLASSIFICATION OF COALS

The Sectional Committee on Classification of Coals, functioning under the procedure of the American Standards Association, continued active work on the collection and correlation of data on the properties of North American coals. At the annual meeting, held in New York City on February 22, 1933, Mr. S. P. Burke of the University of West Virginia, Mr. T. A. Hendricks of the U. S. Geological Survey, and Mr. W. A. Selvig of the U. S. Bureau of Mines were elected members of the Technical Committee on Scientific Classification of Coal; also, Mr. Selvig was elected executive secretary of the Scientific Committee. The chairman of the sectional committee was authorized to appoint a Technical Committee on Nomenclature and the following were appointed and approved by the Executive Committee:

E. A. Holbrook, chairman
G. H. Ashley
H. N. Eavenson
W. H. Fulweiler
T. W. Harris, Jr.
T. A. Hendricks
M. M. Leighton
H. J. Rose
E. Stansfield
F. R. Wadleigh

The technical committees held two group meetings, one in Atlantic City on October 10, 1932, and the other in New York City on February 21 and 22, 1933. The work accomplished by these committees is described below.

Activities of Technical Committees

Technical Committee on Use Classification (W. H. Fulweiler, chairman).—The committee's investigation of the grades and classes of coal used in steam generating plants, and on factors affecting the use of coal with different types of stokers and furnaces was completed and presented by Mr. T. W. Harris, Jr., at the Coal Division meeting of the A.I.M.E. in February, 1933.[1] A supplementary report on the use of pulverized lignite for steam generation was presented by Mr. A. W. Gauger at the February meeting of the committee and progress reports of the work being done at the Fuel Research Laboratories of the Mines Department of Canada on methods for determining the friability and the grindability of coals will be published by the department as mimeographed memorandum reports before July 1, 1933.

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[1] **T. W. Harris, Jr., "Use Classification of Coal for Stationary Steam Generation," *Transactions*, Coal Division, Am. Inst. Mining and Metallurgical Engrs. (1933).**

Technical Committee on Scientific Classification (H. J. Rose, chairman).—This committee has continued active work through its various subcommittees.

Subcommittee I on Nature, Location and Mode of Occurrence has continued to receive the hearty cooperation of various organizations in determining the composition and properties of coals on which information is lacking. The U. S. Bureau of Mines in cooperation with the Anthracite Institute completed a survey of Pennsylvania anthracites. The Canadian associates of the committee are extending their work on Canadian coals and the Illinois Geological Survey is making a comprehensive re-examination of Illinois coals with special reference to their classification.

Subcommittee II on Methods of Analysis, Origin and Composition of Coal completed its original assignments and presented two reports, Nos. 5 and 6, to the Scientific Committee. Report No. 5, "Recommendations on Testing Coal for Classification," relates to the methods of testing to be used in classification and discusses probable errors, tolerances and significance of the various tests. Report No. 6, "Recommendations on Type Classification of Coal," outlines a scheme for classifying coal according to the nature of the plant components and the conditions attending their deposition and alteration during the peat-formation stage.

The Bureau of Mines continued to study the constitution and carbonizing properties of typical American coals and published reports on seven additional coals.[1, 2, 3, 4, 5, 6, 7] In cooperation with

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[1] A. C. Fieldner, J. D. Davis, R. Thiessen, E. B. Kester, W. A. Selvig, D. A. Reynolds, F. W. Jung and G. C. Sprunk, "Carbonizing Properties and Constitution of Washed and Unwashed Coal from Mary Lee Bed, Flat Top, Jefferson County, Ala.," U. S. Bureau of Mines *Technical Paper No. 519* (1932).

[2] A. C. Fieldner, *et al*, "Carbonizing Properties and Constitution of Pittsburgh Bed Coal from Edenborn Mine, Fayette County, Pa.," U. S. Bureau of Mines *Technical Paper No. 525* (1932).

[3] A. C. Fieldner, *et al*, "Carbonizing Properties and Constitution of Number 6 Bed Coal from West Frankfort, Franklin County, Ill.," U. S. Bureau of Mines *Technical Paper No. 524* (1932).

[4] A. C. Fieldner, *et al*, "Comparison of Carbonizing Properties of Pittsburgh Bed Coal from the Allison Mine, Fayette County, Pa., and of a Coking Coal from the Michel Mine, British Columbia, as Determined with the Bureau of Mines Test Retort and Canadian Department of Mines 2-ton Experimental Oven," U. S. Bureau of Mines *Technical Paper No. 543* (1932).

[5] A. C. Fieldner, *et al*, "Carbonizing Properties and Constitution of Black Creek Bed Coal from Empire Mine, Walker County, Ala.," U. S. Bureau of Mines *Technical Paper No. 531* (1932).

[6] A. C. Fieldner, *et al*, "Carbonizing Properties and Constitution of Chilton Bed Coal from the Boone No. 2 Mine, Logan County, Ky.," U. S. Bureau of Mines *Technical Paper No. 542* (1932).

[7] A. C. Fieldner, *et al*, "Carbonizing Properties of Davis Bed Coal from Garrett County Md., and of Mixtures with Pittsburgh Bed Coal," U. S. Bureau of Mines *Technical Pape No. 511* (1932).

Committee D-5 of the American Society for Testing Materials, the Pittsburgh Station of the Bureau of Mines has made a comprehensive investigation of methods for determining the agglutinating index of coal. The results of this investigation will be presented at the June meeting of the Society. It appears that both the agglutinating and the slacking properties of coals must be recognized in classifying coal. Hence, the standardization of these tests is important.

Subcommittee IV on Tentative Classification of Coals submitted a report recommending a tentative scheme for the classification of North American coals according to rank and type. This report was accepted by the scientific committee as a basis for further development by a new subcommittee to be known as Subcommittee V on Boundary Lines for Coal Classification. This new subcommittee is to make a special study of disputed boundary lines between classes of coal and to recommend definite criteria for each class. At the same time the new Technical Committee on Nomenclature is charged with the difficult task of assigning names to these classes. It is hoped to have the reports of these committees available at the fall meeting in order that a tentative scheme for classification may be presented to the sectional committee at the next annual meeting in February, 1934.

Respectfully submitted on behalf of the sectional committee,

A. C. FIELDNER,
Chairman.

C. B. HUNTRESS,
Secretary.

REPORT OF COMMITTEE D-7

ON

TIMBER

Committee D-7 on Timber, through its various subcommittees, reports the following activities:

Subcommittee I on Specifications for Timber (C. E. Paul, chairman).—Subcommittee I has completed its work in connection with size revision of the Standard Specifications for Structural Wood Joist and Planks, Beams and Stringers, and Posts and Timbers (D 245 - 30). This work has been done in connection with Committee VII of the American Railway Engineering Association. At a joint meeting of these committees of the A.R.E.A. and A.S.T.M. held in Chicago on October 7, 1932, the proposed revisions appearing in the Appendix were approved. The committee recommends these revisions which clarify various clauses of the existing standard specifications for immediate adoption.

This subcommittee has done additional work in connection with the Tentative Specifications for Timber Piles (D 25 - 30 T). Recognizing the limited scope of the present tentative specifications, the subcommittee has attempted to broaden the field of application for piling to include piles used for lighter load bridges and buildings. A thorough survey of the specifications used at the present time by the various bodies has indicated that there is a total lack of agreement and that it will be necessary to pursue the subject for another year. The subcommittee is endeavoring to formulate three classes of piling as follows: piling for heavy work such as railways, docks and wharves, etc.; piling for medium work, such as heavy highway traffic and buildings; and piling for light work of various kinds. In view of the importance of this subject, it is recommended that the Tentative Specifications for Timber Piles (D 25 - 30 T) be continued as tentative for another year.

Subcommittee VI on Timber Preservatives (S. R. Church, chairman).—During the year, this subcommittee has made a careful comparative study of the standard and tentative standard methods for sampling and analysis of creosote oil now published by the American Wood-Preservers' Association, the American Railway Engineering Association and the American Society for Testing Materials. Consideration has also been given to a deficiency in the Society's methods of sampling creosote oil and to certain changes in methods of testing, notably insoluble matter in creosote and specific gravity of creosote fractions recently adopted by the American Wood-Preservers' Association. This work has resulted in the recommendations mentioned later in this report, and described in detail in the report of the subcommittee appended hereto, to revise the standard methods of testing creosote oil. The volume and specific gravity correction tables for creosote and the definitions of terms relating to timber preservatives, now tentative, are being recommended for advancement to standard.

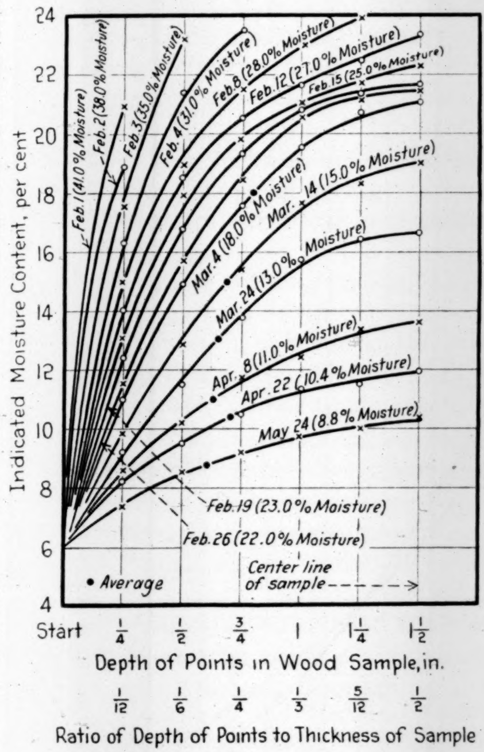

FIG. 1.—**Indicated Moisture Contents at Different Depths. Black gum—3-in. thick.**

NOTE.—The percentage in parenthesis following the date on each curve indicates the moisture content based on oven-dry weight.

Dimensions of sample: 3 by 6¾ by 14 in. at start; 2¾ by 6⅝ by 14 in. at end.

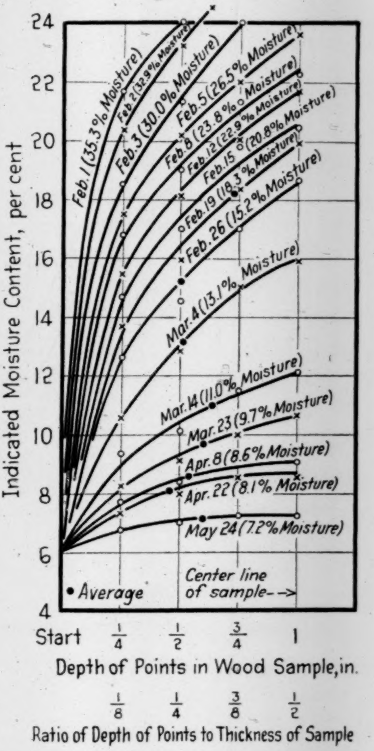

FIG. 2.—**Indicated Moisture Contents at Different Depths. Black gum—2-in. thick.**

NOTE.—The percentage in parenthesis following the date on each curve indicates the moisture content based on oven-dry weight.

Dimensions of sample: 2 by 8½ by 14 in. at start; 1⅞ by 8$\frac{1}{16}$ by 14 in. at end.

Subcommittee XI on Moisture Content of Timber (M. E. Dunlap, chairman).—Subcommittee XI has continued its investigations. A small amount of work was done during 1932 at the Forest Products Laboratory to study the application of electrical measurements to heavy timber. The calibration work previously done was on material 1 in. in thickness or on heavier material in which it was known that the moisture was evenly distributed. Some measurements were made on 2- and 3-in. black gum which were drying at a relative humidity of 30 per cent and were approaching a moisture content of

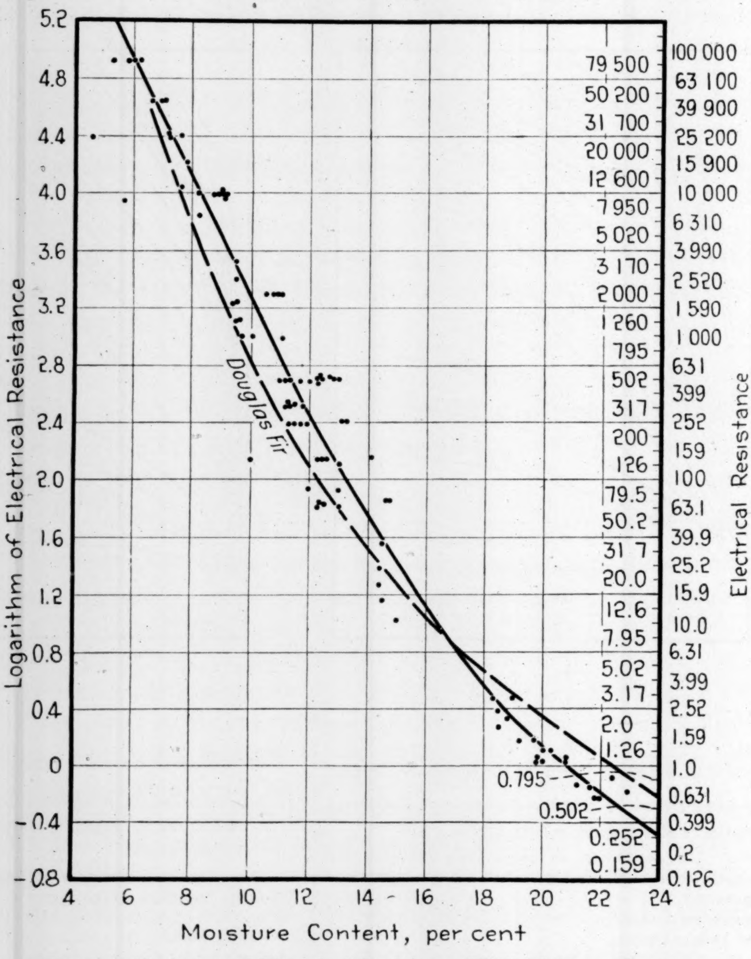

FIG. 3.—Variation of Electrical Resistance With Moisture Content.

Values of electrical resistance are in megohms.

6 per cent. Points were driven into the sample blocks to different depths and measurements were made at these points periodically during the drying process. Figures 1 and 2 show the results of these determinations. Figure 3 shows the variation in electrical resistance with moisture content. For the purpose of comparison, the curve for Douglas fir appears also on Fig. 3.

The main points of interest brought out were that it is possible to obtain an approximate idea of the moisture content at any particular depth by setting a pair of electrodes to that depth, and that the average moisture content of a heavy timber can be learned approximately by setting two electrodes to a depth equal to about one fourth of the thickness of the lumber. This measurement becomes less accurate above an average moisture content of 18 per cent.

The critical electrical measurement is made at the electrode in the driest wood and at the wettest point of this electrode. For instance, where a drying gradient exists and two electrodes are driven into a timber to a depth of $\frac{1}{2}$ in. and 1 in. respectively, the critical measurement will be made at the point of the $\frac{1}{2}$-in. electrode. The distance between electrodes does not seem to be critical, at least not up to distances of 10 or 12 in., according to these experiments.

RECOMMENDATIONS AFFECTING STANDARDS

I. *Proposed Revisions of Standards.*—The committee recommends that the revisions in the following specifications and methods of test as proposed by Subcommittees I and VI be adopted immediately and the standards as revised be continued as standard. The committee accordingly asks for the necessary nine-tenths vote at the annual meeting in order that these recommended revisions may be submitted to letter ballot of the Society for immediate adoption:

Standard Specifications for Structural Wood Joist and Planks, Beams and Stringers, and Posts and Timbers (D 245 - 30),[1] revised in accordance with the Appendix as proposed by Subcommittee I;

Standard Methods of Sampling and Analysis of Creosote Oil (D 38 - 30),[1] revised as proposed by Subcommittee VI; and

Standard Method of Test for Distillation of Creosote Oil (D 246 - 30),[1] revised as proposed by Subcommittee VI.

II. *Advancement of Tentative Standards to Standard.*—The committee recommends for adoption as standard the following tentative standards under its jurisdiction:

Tentative Method of Test for the Determination of the Specific Gravity, 38/15.5 C., of Creosote Fractions (D 38 - 30 T),[2] revised as proposed by Subcommittee VI;

Tentative Definitions of Terms Relating to Timber Preservatives (D 324 - 30 T),[2] revised as proposed by Subcommittee VI; and

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[1] 1930 Book of A.S.T.M. Standards, Part II, pp. 754, 874, 885.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, pp. 1152, 1154 (1930); also 1932 Book of A.S.T.M. Tentative Standards, pp. 718, 724.

Tentative Volume and Specific Gravity Correction Tables for Creosote, Creosote Coal-Tar Solution (up to 50 per cent Tar) and Coal Tar (Coke-Oven Tars) (D 347 – 32 T),[1] without revision.

III. *Advancement of Tentative Revision of Standard to Standard.*—The committee recommends the advancement to standard of the tentative revision of the Standard Method of Test for Distillation of Creosote Oil (D 246 – 30), as proposed by Subcommittee VI in its report appended hereto.

The recommendations appearing in this report have been submitted to letter ballot of the committee, which consists of 24 members, with the following results:

Items	Affirmative	Negative	Not Voting
I. PROPOSED REVISIONS OF STANDARDS			
Specifications for Structural Wood Joist and Planks, Beams and Stringers, and Posts and Timbers (D 245 – 30), immediate adoption	24	0	0
Methods of Sampling and Analysis of Creosote Oil (D 38 – 30), immediate adoption	19	0	5
Method of Test for Distillation of Creosote Oil (D 246 – 30), immediate adoption	19	0	5
II. ADVANCEMENT OF TENTATIVE STANDARDS TO STANDARD			
Method for the Determination of the Specific Gravity, 38/15.5 C., of Creosote Fractions (D 38 – 30 T), as revised	20	0	4
Volume and Specific Gravity Correction Tables for Creosote, Creosote Coal-Tar Solution (up to 50 per cent Tar) and Coal Tar (Coke-Oven Tars) (D 347 – 32 T)	20	0	4
Definitions of Terms Relating to Timber Preservatives (D 324 – 30 T)	19	0	5
III. ADVANCEMENT OF TENTATIVE REVISION OF STANDARD TO STANDARD			
Method of Test for Distillation of Creosote Oil (D 246 – 30)	18	0	6

This report has been submitted to letter ballot of the committee, which consists of 24 members; 24 members returned their ballots, of whom 21 have voted affirmatively and none negatively.

Respectfully submitted on behalf of the committee,

HERMANN VON SCHRENK,
Chairman.

J. A. NEWLIN,
Secretary.

EDITORIAL NOTE

Revisions proposed for immediate adoption in the Standard Specifications for Structural Wood Joist and Planks, Beams and Stringers, and Posts and Timbers, Methods of Sampling and Analysis of Creosote Oil and Test for Distillation of Creosote Oil, were approved at the annual meeting by a unanimous vote and were subsequently adopted by letter ballot of the Society on September 1, 1933. The standards in their revised form appear in the 1933 Book of A.S.T.M. Standards, Part II, pages 347, 470, and 477, respectively.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 797 (1932); also 1932 Book of A.S.T.M. Tentative Standards, p. 720.

The Tentative Method for the Determination of the Specific Gravity, 38/15.5 C., of Creosote Fractions, as revised, and the Tentative Volume and Specific Gravity Correction Tables for Creosote, Creosote Coal-Tar Solution (up to 50 per cent Tar) and Coal Tar (Coke-Oven Tars) were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1933, and appear in the 1933 Book of A.S.T.M. Standards, Part II, pages 488 and 491, respectively.

With the exception of the definition for water-gas tar, the Tentative Definitions of Terms Relating to Timber Preservatives, with a modification in the definition for coal tar proposed on the floor of the annual meeting, see Summary of Proceedings, page 6, were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1933, and appear in the 1933 Book of A.S.T.M. Standards, Part II, page 503. The definition of the term water-gas tar was continued as a tentative revision of the standard definitions and appears on page 1035.

The tentative revision of the Standard Method of Test for Distillation of Creosote Oil was approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1933. The method in its revised form appears in the 1933 Book of A.S.T.M. Standards, Part II, page 477.

APPENDIX

PROPOSED REVISIONS IN STANDARD SPECIFICATIONS FOR STRUCTURAL WOOD JOIST AND PLANKS, BEAMS AND STRINGERS, AND POSTS AND TIMBERS (D 245 - 30)[1]

Introduction to Structural Rules.—Change the Sizes of Joist and Plank, Beams and Stringers, and Posts and Timbers from their present form: namely,

Sizes of Joist and Plank

(Joist, Rafters, Scaffold Plank, Factory Flooring, etc.)

Nominal thickness	2 to 4 in.
Nominal widths	4 in. and wider
Standard thickness	S1S or S2S: ⅜ in. off
Standard widths	4 to 7 in., S1E or S2E: ⅜ in. off 8 in. and wider, S1E or S2E: ½ in. off

Sizes of Beams and Stringers

(Beams, Girders, Stringers, etc.)

Nominal thickness	5 in. and thicker
Nominal widths	8 in. and wider

Sizes of Posts and Timbers

(Posts, Caps, Sills, Timbers, etc.)

Nominal sizes	6 by 6 in. and larger

to read as follows:

Sizes of Joist and Plank

(Joist, Rafters, Scaffold Plank, Factory Flooring, etc.)

Standard nominal thicknesses	2, 2½, 3, and 4 in.
Standard nominal widths	4 in. and wider in multiples of 2 in.
Standard dressed thicknesses, S1S or S2S	⅜ in. off[a]
Standard dressed widths, S1E or S2E	4 to 7 in., ⅜ in. off[a] 8 in. and wider, ½ in. off[a]

Sizes of Beams and Stringers

(Beams, Girders, Stringers, etc.)

Standard nominal thicknesses	5 in., 6 in., and thicker in multiples of 2 in.
Standard nominal widths	8 in. and wider in multiples of 2 in.
Standard dressed sizes, S1S, S1E, S2S, or S4S	½ in. off[a]

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[1] These proposed revisions in the Standard Specifications for Structural Wood Joist and Planks, Beams and Stringers, and Posts and Timbers (D 245 - 30) are being recommended for immediate adoption. The specifications as issued in 1930 appear in the 1930 Book of A.S.T.M. Standards, Part II, p. 754.

Sizes of Posts and Timbers

(Posts, Caps, Sills, Timbers, etc.)

Standard nominal sizes..............6 by 6 in. and larger in multiples of 2 in.
Standard dressed sizes, S1S, S1E, S2S, or S4S..........................$\frac{1}{2}$ in. off[a]

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[a] Lumber is dressed by running it through a planer and may be surfaced on one side (S1S), surfaced on two sides (S2S), surfaced on one edge (S1E), surfaced on two edges (S2E), or surfaced on a combination of sides and edges, (S1S1E), (S2S1E), (S1S2E), or (S4S). The standard minimum dressed dimension is the nominal size less the allowance for surfacing. In addition to providing a smooth surface, a further purpose in dressing lumber is to bring each piece to standard uniform dimensions throughout its length, and also to bring all pieces to the same dimensions. For these reasons, and because of the method of manufacture and planing, the allowance for surfacing is the same regardless of whether one or two opposite faces are surfaced. If a 2 by 8-in. joist is S1S or S2S, the minimum dressed thickness is 1$\frac{5}{8}$ in., the width remaining the standard rough dimension; that is, the nominal width of 8 in., subject to the occasional slight variation in sawing permitted (Section 1B); if S1E or S2E, the minimum dressed width is 7$\frac{1}{2}$ in., the thickness remaining the standard rough dimension; that is, the nominal thickness of 2 in., subject to the occasional slight variation in sawing permitted (Section 1B); and if S1S1E, S2S1E, S1S2E, or S4S, the piece is dressed to the minimum size in both dimensions. The dressed dimensions apply to the moisture condition existing in the piece at the time of dressing, so that any subsequent drying will result in some shrinkage. Whether scantness of size is due to shrinkage or to overdressing may usually be determined by soaking the piece in water. If dressed originally to standard size, the soaked pieces will return to at least that size.

Make the following changes in Part B. Specification Requirements for Structural Wood Joist and Planks, Beams and Stringers, and Posts and Timbers:

Section 1A.—Change to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

1A. Structural joist and plank [shall be] when [surfaced] S1S or S2S *shall* not *be* thinner than the nominal [dimension] *thickness* less $\frac{3}{8}$ in., and when [surfaced] S1E or S2E not narrower than the nominal width less $\frac{3}{8}$ in. [for sizes 2] *in pieces 4* to 7 in. *in width*, inclusive, and less $\frac{1}{2}$ in. [for sizes] *in pieces* 8 in. and wider.

Make this same change in Section 1*A* which also appears[1] under Part C in the Typical Specification for Common Structural Joist and Plank with Wane Permissibility and No Heartwood or Sapwood Requirement, Surfaced S1S, S1E.

Section 1B.—Change from its present form: namely,

1*B*. Rough structural joist and plank shall not be thinner than the nominal dimension less $\frac{1}{4}$ in. and not narrower than the nominal width less $\frac{1}{4}$ in. for sizes 2 to 7 in., inclusive, and less $\frac{3}{8}$ in. for sizes 8 in. and wider.

to read as follows:

1*B*. Rough structural joist and plank shall be sawed full to nominal dimensions, except that occasional slight variation in sawing is permissible. However, at no part of the length shall any piece, because of such variation in sawing, be thinner than the nominal thickness less $\frac{1}{8}$ in. in pieces 2 in. in thickness, and less $\frac{3}{16}$ in. in pieces 3 and 4 in. in thickness, nor narrower than the nominal width less $\frac{3}{16}$ in. in pieces 4 to 7 in. in width, inclusive, and less $\frac{1}{4}$ in. in pieces 8 in. and wider. Further, no shipment shall contain more than 20 per cent of pieces of minimum dimensions.

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 777.

Section 2A.—Change to read as follows by the addition of the italicized words and the omission of the words and figures in brackets:

2A. Structural beams and stringers [shall be] when [surfaced] S1S, S1E, S2S, or S4S *shall* not *be* smaller than the nominal [size less ⅜ in. for sizes 7 in. and less, and] *dimensions* less ½ in. [for sizes 8 in. and over].

Section 2B.—Change from its present form: namely,

2*B*. Rough structural beams and stringers shall not be smaller than the nominal size less ¼ in. for sizes 7 in. and less, and less ⅜ in. for sizes 8 in. and over.

to read as follows:

2*B*. Rough structural beams and stringers shall be sawed full to nominal dimensions, except that occasional slight variation in sawing is permissible. However, at no part of the length shall any piece, because of such variation in sawing, be smaller than the nominal dimensions less $\frac{3}{16}$ in. in pieces 5 and 6 in. in dimensions, and less ¼ in. in pieces 8 in. and larger. Further, no shipment shall contain more than 20 per cent of pieces of minimum dimensions.

Make this same change in Section 2*B* which also appears[1] under Part C in the Typical Specifications for Dense Select Structural Beams and Stringers (Southern Pine) with Square Edges and Heartwood Requirement for Use Untreated, Rough.

Section 3A.—Change to read as follows by the addition of the italicized words and the omission of the words and figures in brackets:

3A. Structural posts and timbers [shall be] when [surfaced] S1S, S1E, S2S, or S4S *shall* not *be* smaller than the nominal [size less ⅜ in. for sizes 7 in. and less, and] *dimensions* less ½ in. [for sizes 8 in. and over].

Make this same change in Section 3*A* which also appears[2] under Part C in the Typical Specification for Select Structural Posts and Timbers (Douglas Fir) with Wane Permitted and Sapwood Wanted for Treatment, Surfaced Four Sides.

Section 3B.—Change from its present form: namely,

3*B*. Rough structural posts and timbers shall not be smaller than the nominal size less ¼ in. for sizes 7 in. and less, and less ⅜ in. for sizes 8 in. and over.

to read as follows:

3*B*. Rough structural posts and timbers shall be sawed full to nominal dimensions, except that occasional slight variation in sawing is permissible. However, at no part of the length shall any piece, because of such variation in sawing, be smaller than the nominal dimensions less $\frac{3}{16}$ in. in pieces 6 in. in dimensions and less ¼ in. in pieces 8 in. and larger. Further, no shipment shall contain more than 20 per cent of pieces of minimum dimensions.

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 771.

[2] *Ibid.*, p. 774.

REPORT OF SUBCOMMITTEE VI ON TIMBER PRESERVATIVES

Subcommittee VI has been considering for some years the question of recommending that all of the separate test methods now appearing in the Standard Methods of Sampling and Analysis of Creosote Oil (D 38 - 30) be issued as separately designated methods. The subcommittee is now definitely recommending such action and in this report a statement will be made in connection with each method as to the necessary changes, including paragraphs on scope, required to carry out the new plan.

This report also includes reference to such minor changes as are recommended in line with uniformity and a full description of the proposed revisions or additions to existing methods. None of the proposed revisions involve the adoption of any new or untried methods and since these recommendations are the outcome of several years' cooperative work on the part of the Preservatives Committee of the American Wood-Preservers' Association, the American Railway Engineering Association and this subcommittee, as mentioned previously in the report of Committee D-7, it is believed that all of the revised methods herein referred to should be maintained or advanced to standard. The volume and specific gravity correction tables for creosote and the definitions of terms relating to timber preservatives are being recommended for advancement to standard.

Advancement of Tentative Standards to Standard:

Tentative Definitions of Terms Relating to Timber Preservatives (D 324 - 30 T).[1]—These definitions have been tentative for three years and no criticism has been received by the committee. In the meantime they have been adopted as standard by the American Wood-Preservers' Association. The subcommittee believes that creosote definitions are particularly useful as a background for creosote specifications. With the exception of the definition for water-gas tar which will be continued as tentative,[2] the terms defined in these definitions are recommended for adoption as standard with the following revision in the definition for coal tar:

Change the definition for coal tar from its present form: namely,

Tar, Coal.—The nonaqueous portion of the liquid distillate obtained during the carbonization of bituminous coal.

to read as follows:

Coal Tar.—Tar produced by the destructive distillation of bituminous coal.

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[1] *Proceedings,* Am. Soc. Testing Mats., Vol. 30, Part I, p. 1154 (1930); also 1932 Book of A.S.T.M. Tentative Standards, p. 724.

[2] See p. 1035.—Ed.

Tentative Method of Test for the Determination of Specific Gravity of Creosote Fractions (D 38 - 30 T).[1]—The subcommittee is revising this method by including a paragraph on scope, and by the addition of a modified procedure suitable for fractions containing solids at 38 C. The method in its revised form as appended hereto[2] is recommended for advancement to standard for publication under a separate serial designation.

Tentative Volume and Specific Gravity Correction Tables for Creosote, Creosote Coal-Tar Solution (up to 50 per cent Tar) and Coal Tar (Coke-Oven Tars) (D 347 - 32 T).[3]—In previous reports[4] the development of these correction tables has been fully described. The tables have been widely commended as helpful to the wood-preserving industry and no criticism has been received. These tables have already been adopted as standards by the American Wood-Preservers' Association and by the American Railway Engineering Association. This subcommittee recommends that the tables be advanced to standard.

Proposed Revisions of Standards:

Standard Methods of Sampling and Analysis of Creosote Oil (D 38 - 30).[5]—These standard methods are being modified by the inclusion of a routine zone method of sampling creosote in tank cars and the endorsement of the standard methods of the A.W.P.A. and the A.R.E.A. as a referee method of sampling tank cars in case of dispute. The subcommittee is also proposing changes, as described in detail below, in the tests for water, insoluble matter and specific gravity. Methods D 38 as thus revised will comprise the methods of sampling and a listing of the various methods of testing creosote, which testing procedures will be published as separate standards. These modifications are shown in the revised methods appended hereto[6] which are recommended for immediate adoption as standard to replace the present Standard Methods D 38 - 30, this recommendation requiring a nine-tenths vote at the annual meeting.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 1152 (1930); also 1932 Book of A.S.T.M. Tentative Standards, p. 718.

[2] The method as revised appears in the 1933 Book of A.S.T.M. Standards, Part II, p. 488.—ED.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 797 (1932); also 1932 Book of A.S.T.M. Tentative Standards, p. 720.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 504 (1931), and Vol. 32, Part I, p. 448 (1932).

[5] 1930 Book of A.S.T.M. Standards, Part II, p. 874.

[6] The method as revised appears in the 1933 Book of A.S.T.M. Standards, Part II, p. 470.—ED.

Test for Water.—The subcommittee recommends that the tentative revision of the water test proposed in 1929 be advanced to standard. The subcommittee also recommends that a section on scope be added to this test as revised and the method published as a separate standard. The new scope section and the revision in the water test are as follows:

> 1. *Scope.*—This is an accurate method for determining the percentage of water in creosote and creosote coal-tar solution. Its use is indicated for dehydrating creosote containing more than 3 per cent of water in preparation for the distillation test. The alternative test is more convenient and rapid where the determination of water only is required.

Section 4.—Change the last sentence of the first paragraph to read as follows by the addition of the italicized figure and the omission of the words and figures in brackets:

> If more than [2]*3* per cent of water is present, [or if the water is apparently present to an extent in excess of 2 per cent, but an accurate separation is impossible,] the percentage of water present shall be determined by the following method, and the water-free oil so obtained shall be used in the distillation test:

Matter Insoluble in Benzol.—The subcommittee has carefully considered the recommendation of an alternative method for determining insoluble matter in creosote as adopted by the A.W.P.A. in 1933. This consists essentially of the alternative use of the Gooch crucible in place of the present extraction flask, resulting in a considerable saving in time without sacrificing accuracy. These changes have been incorporated in the revised method appended hereto[1] which it is recommended be published as a separate standard.

Specific Gravity.—The permissible variations in dimensions of the hydrometer and cylinder have been changed to conform to those recommended by the A.W.P.A. It is also recommended that the tentative revision published in 1932 be adopted. This revision provides for correction for temperature through reference to the new correction tables, and eliminates the arbitrary correction factor given in the present methods. These changes have been incorporated in the revised method appended hereto[2] which is recommended for publication as a separate standard.

Standard Method of Test for Distillation of Creosote Oil (D 246 - 30).[3]—The committee recommends the advancement to standard of the tentative revision in this method proposed in 1929, which reads as follows:

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[1] The method as revised appears in the 1933 Book of A.S.T.M. Standards, Part II, p. 483.—ED.

[2] The method as revised appears in the 1933 Book of A.S.T.M. Standards, Part II, p. 486.—ED.

[3] 1930 Book of A.S.T.M. Standards, Part II, p. 885.

Section 8.—Change the phrase "If the presence of water is suspected or known" to read "If the presence of 3 per cent of water is suspected or known."

Section 10.—Add a new paragraph to read as follows:

(*f*) If the fraction 0 to 210 C. contains water the amount of water shall be determined. This amount shall then be deducted from the weight of oil taken and all of the fractions shall be corrected to a percentage based on dry oil. A convenient method for determining the amount of water is to transfer this fraction, after weighing, to a tube or cylinder graduated in 0.1 cc. and add about 15 to 20 cc. of benzol. This almost always causes a clear separation between the oil and water.

It is also recommended that the accompanying Table I showing the corrections to be made in the distillation temperatures for altitudes at elevations of 1000 ft. or over be incorporated in this method immediately, this recommendation requiring a nine-tenths vote at the annual meeting. These corrections have been calculated by the Forest Products Laboratory, U. S. Department of Agriculture, and confirmed by experiments at four industrial laboratories, two located at sea level and two at elevations of 4000 to 5000 ft. This table has been adopted by the A.W.P.A. and A.R.E.A. With these changes, the subcommittee recommends the continuation of this method as standard.

New Section.—Add the following paragraph and table as a new Section 11.

11. *Distillation Temperatures at Various Altitudes.*—If the elevation at which the distillation is to be made exceeds 1000 ft., the temperatures at which the fractions are taken shall be corrected in accordance with Table I.

TABLE I.—TEMPERATURES AT WHICH CREOSOTE FRACTIONS SHOULD BE CUT TO CORRECT DISTILLATION TEMPERATURES FOR DIFFERENT ALTITUDES.
(Corrections made to the nearest 1 C.)

Elevation Above Sea Level, ft.	Fractionation Temperatures for Various Altitudes					
0	200 C.	210 C.	235 C.	270 C.	315 C.	355 C.
1000	198	208	233	268	313	353
1500	197	207	232	267	312	352
2000	196	206	231	266	311	351
2500	196	206	230	265	310	350
3000	195	205	230	264	309	349
3500	194	204	229	263	308	348
4000	193	203	228	263	307	347
4500	193	202	227	262	306	346
5000	192	202	226	261	305	344
5500	191	201	225	260	304	343
6000	190	200	225	260	303	343

Standard Method of Test for Coke Residue of Creosote Oil (D 168 - 30).[1]—The following section on scope is proposed for addition to this method as a new Section 1. With this minor editorial improvement it is recommended that the method be continued as standard:

> 1. *Scope.*—This method is an accurate means for determining coke residue (fixed carbon) in creosote or creosote coal-tar solution by coking the residue resulting from the distillation test and calculating the result based on the original oil.

The subcommittee believes that the proposed alterations in the present methods of sampling and analysis of creosote oil, although not contemplating any radical or unusual departures from present practice, will result in a more complete and more readily useable form of standard methods. It is also believed that through the joint efforts with the Preservatives Committee of the A.W.P.A. substantial unity in form as well as in substance have been obtained. The subcommittee will continue its study of the refinements and details of all of those methods but believes that with the proposed changes the methods will not require alteration for some time.

Respectfully submitted on behalf of the subcommittee,

S. R. CHURCH,
Chairman.

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 882.

REPORT OF COMMITTEE D-8

ON

BITUMINOUS WATERPROOFING AND ROOFING MATERIALS

Because of the very general interest in accelerated weathering tests on bituminous materials, Committee D-8, in its 1931 and 1932 annual reports, published progress reports from Subcommittee VIII on Accelerated Weathering Tests. This subcommittee has actively continued its work during the past year and has obtained valuable information regarding the radiant energy of the two types of lamps which have been used in this work. This information is considered of sufficient interest to warrant publication as an appendix to this report. The subcommittee has also prepared a detailed description of a Proposed Method for Accelerated Weathering Tests on Bituminous Materials. While Committee D-8 is not at this time prepared to recommend this method for acceptance as a tentative standard, it believes that it should be published as information, and it is therefore appended to this report.

RECOMMENDATIONS AFFECTING STANDARDS

I. Proposed Tentative Standard:

Proposed Tentative Specifications for Asphalt Cap Sheet Surfaced with Mineral Granules.—The committee recommends for publication as tentative the proposed Specifications for Asphalt Cap Sheet Surfaced with Mineral Granules as appended hereto.[1] These specifications are intended to cover a material which has recently come into use as a cap sheet for finishing built-up roof coverings where gravel or similar surfacing is not used and where a cap sheet is considered preferable to an asphalt coating mopped on after the covering is applied.

II. Proposed Revisions of Standards:

Standard Specifications for Asphalt Roll-Roofing Surfaced with Powdered Talc (D 224 - 27).[2]—In order to provide for more reliable tests for physical properties of the roll-roofing the committee proposes the following revision of these specifications and recommends that the specifications as revised be reverted to tentative:

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[1] See p. 778.—Ed.

[2] 1930 Book of A.S.T.M. Standards, Part II, p. 934.

Section 7.—Change Paragraphs (*e*) and (*g*) to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

(*e*) Pliability at 77 F. (25 C.).—At least [four] *eight* strips out of [five] *ten* shall not crack [on 10-mm. mandrel] *when bent 90 deg. at a uniform speed over a rounded corner of ½-in. radius.*

(*g*) Saturant in Moisture-free Felt.—Medium and heavy weights, minimum, [140] *150* per cent by weight.

Standard Specifications for Asphalt Roll-Roofing and Asphalt Shingles Surfaced with Mineral Granules (D 225 – 29).[1]—In order to conform more closely with approved commercial practice the committee proposes the following revision of these specifications and recommends that the specifications as revised be reverted to tentative:

Section 7.—Change Paragraphs (*c*), (*d*), (*g*) and (*i*) to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

(*c*) Weight of Wrapping and Packing Material per "Square":

Mineral-Surfaced Roll including nails and lap-cement, maximum, 4 lb.

NOTE.—Special fixtures may be furnished in lieu of nails and cement, if agreed upon by the purchaser and seller, in which event the above weights may be increased.

Shingles (packing only), maximum [12] *15* lb.

(*d*) Weight of Material per 108 sq. ft. Exclusive of Wrapping, Packing, Loose Mineral Surfacing, Nails and Cement:

Mineral-Surfaced Roll [and Shingles].—Average, not less than 82 lb.; minimum, 80 lb.

Shingles.—Average, not less than 85 lb.; minimum 83 lb.

(*g*) Saturant in Moisture-Free Felt:

Mineral-Surfaced Roll, minimum, [140] *150* per cent by weight.

Shingles, minimum, [150] *175* per cent by weight.

(*i*) Ash in Moisture-Free Desaturated Felt.—Maximum [10] *12* per cent *by weight.*

Standard Specifications for Asphalt Roll-Roofing Surfaced with Granular Talc (D 248 – 27).[2]—In order to provide for more reliable tests for physical properties of the roll-roofing the committee proposes the following revision of these specifications and recommends that the specifications as revised be reverted to tentative:

Section 7.—Change Paragraphs (*e*), (*g*) and (*i*) to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 942.

[2] *Ibid*, p. 938.

(*e*) Pliability at 77 F. (25 C.).—At least [3] ***eight*** strips out of [5] ***ten*** shall not crack [on 10-mm. mandrel] ***when bent 90 deg. at a uniform speed over a rounded corner of ½-in. radius.***

(*g*) Saturant in Moisture-Free Felt.—Medium and Heavy Weights, minimum, [140] ***150*** per cent by weight.

(*i*) Ash in Moisture-Free Desaturated Felt.—Maximum, [10] *12* per cent ***by weight.***

Standard Specifications for Heavy Weight Asphalt Roll-Roofing and Heavy Weight Asphalt Shingles Surfaced with Mineral Granules (D 249 - 27).[1]—In order to provide for more reliable tests in these products the committee proposes the following revision of these specifications and recommends that the specifications as revised be reverted to tentative:

Section 7.—Change Paragraphs (*g*) and (*i*) to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

(*g*) Saturant in Moisture-Free Felt:

Mineral-Surfaced Roll [and Shingles].—Minimum, [170] ***160*** per cent by weight.

Shingles.—Minimum, 175 per cent by weight.

(*i*) Ash in Moisture-Free Desaturated Felt.—Maximum [10] ***12*** per cent ***by weight.***

III. Revision of Tentative Standard:

Tentative Methods of Testing Asphalt Roll-Roofing Surfaced with Fine Talc, Granular Talc, or Mineral Granules; also Asphalt Shingles Surfaced with Mineral Granules (D 228 - 31 T).[2]—In order to meet criticisms received since publication of these methods, the committee recommends that they be revised as follows and continued as tentative:

Section 20.—Omit this section which deals with the weight of moisture-free felt (C-I). Transpose to the end of the present Section 21 the Note which now appears at the end of Section 20.

Section 22.—Renumber this section as 20 and change the third sentence of Paragraph (*b*) to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

> The desaturated felt shall be removed from the extractor, placed in a tared weighing bottle, [heated until free from moisture and weighed as described in Section 20] ***provided with a ground-glass stopper, heated in a ventilated oven at 225 F. ±5 F. (107 C. ±3 C.) for 30 minutes, the stopper inserted, then cooled and weighed. The heating shall be repeated until the weight of the felt remains constant as determined by two consecutive weighings taken with an intervening heating period of not less than 10 minutes, which shall show a further loss in weight of not more than 0.1 per cent.***

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 947.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 818 (1931); also 1932 Book of A.S.T.M. Tentative Standards, p. 745.

New Section 22.—Insert the following as a new Section 22:

22. *Moisture-Free Felt* (*C-I*).—The top and bottom horizontal sections separated from the roofing strips as described in Section 20 shall now be extracted separately with benzol (boiling point 80 to 82 C.) or c.p. carbon disulfide in a suitable extractor or centrifuge and the extraction continued until the washings have become colorless. The insoluble residue from each extraction shall be removed and the pieces of felt picked out and brushed free of adhering mineral matter. The clean pieces of felt shall be placed in a tared weighing bottle, heated until free from moisture and weighed as described in Section 20. Calculate the percentage of felt in the roofing from the combined weights obtained in the top and bottom sections and in the middle section obtained under Section 20. From the weight so obtained and the total area of the strips of original desaturated felt (area of strips taken for test under Section 20) compute the weight of moisture-free felt in pounds per 108 sq. ft. by one of the following formulas:

$$\text{Pounds per 108 sq. ft.} = \frac{\text{Weight of felt in grams}}{\text{Area in square centimeters}} \times 221.2$$

or

$$\text{Pounds per 108 sq. ft.} = \frac{\text{Weight of felt in grams}}{\text{Area in square inches}} \times 34.3$$

Section 23.—Change Paragraph (*a*) of this section to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

23. (*a*) [The top and bottom horizontal sections separated from the roofing strips as described in Section 22 shall now be extracted separately with benzol (boiling point 80 to 82 C.) or c.p. carbon disulfide in a suitable extractor or centrifuge and the extraction continued until the washings have become colorless. The insoluble residue from each extraction shall be removed and the pieces of felt picked out and brushed free of adhering mineral matter. The clean pieces of felt shall be placed in a tared weighing bottle, heated until free from moisture and weighed as described in Section 20.] The admixed and embedded mineral matter separated from the felt of each extraction *made under Section 22* shall be dried at 225 F. ± *5 F.* (107 C. ± *3 C.*), cooled in a desiccator and weighed. Calculate the weight of bituminous saturant (B-III) present in the felt contaminating these top and bottom sections, that is, the felt recovered on extraction multiplied by the percentage of bituminous saturation (Section [22] *20* (c)). From the original weight of the top and bottom sections respectively, subtract the combined weights of dry felt, bituminous saturant and embedded and admixed mineral matter. The difference represents the weight of bituminous matter in the surface coating of that particular section. [The percentage of felt in the roofing calculated from the combined weights of felt obtained in each of the three horizontal sections and the original weight of roofing strips taken, should check with the percentage of felt found in Section 20, within 1 per cent. Likewise the percentage of total mineral matter found in the top and bottom sections should check with the percentage found in Section 20 within 1 per cent. The total percentage of bituminous matter found in these three horizontal sections based on the original weight of strips taken should also

agree within 1 per cent with the percentage of total bituminous material calculated in Section 20, from the difference between the original weight of strips taken and the weight of felt and mineral matter found.]

The recommendations appearing in this report have been submitted to letter ballot of the committee, which consists of 45 voting members, with the following results:

Items	Affirmative	Negative	Not Voting
I. PROPOSED TENTATIVE STANDARD			
Tentative Specifications for Asphalt Cap Sheet Surfaced with Mineral Granules........	26	1	4
II. PROPOSED REVISIONS OF STANDARDS			
Specifications for Asphalt Roll-Roofing Surfaced with Powdered Talc (D 224 - 27)......	26	1	0
Specifications for Asphalt Roll-Roofing and Asphalt Shingles Surfaced with Mineral Granules (D 225 - 29)........	25	2	0
Specifications for Asphalt Roll-Roofing Surfaced with Granular Talc (D 248 - 27)......	26	1	0
Specifications for Heavy Weight Asphalt Roll-Roofing and Heavy Weight Asphalt Shingles Surfaced with Mineral Granules (D 249 - 27)........	25	2	0
III. REVISION OF TENTATIVE STANDARD			
Methods of Testing Asphalt Roll-Roofing Surfaced with Fine Talc, Granular Talc or Mineral Granules, also Asphalt Shingles Surfaced with Mineral Granules (D 228 - 31 T)........	23	2	0

This report has been submitted to letter ballot of the committee, which consists of 45 voting members; 31 members returned their ballots, of whom 29 have voted affirmatively and 1 negatively.

Respectfully submitted on behalf of the committee,

J. M. WEISS,
Chairman.

PRÉVOST HUBBARD,
Secretary.

EDITORIAL NOTE

The proposed Tentative Specifications for Asphalt Cap Sheet Surfaced with Mineral Granules were accepted for publication as tentative and appear on page 778.

The proposed revisions of the Standard Specifications for Asphalt Roll-Roofing Surfaced with Powdered Talc, for Asphalt Roll-Roofing and Asphalt Shingles Surfaced with Mineral Granules, for Asphalt Roll-Roofing Surfaced with Granular Talc and for Heavy Weight Asphalt Roll-Roofing and Heavy Weight Asphalt Shingles Surfaced with Mineral Granules were accepted together with the recommendation, proposed on the floor of the annual meeting, see Summary of Proceedings, page 18, that the four specifications be discontinued as standards and reverted to the tentative status. The specifications in their revised form appear as tentative on pages 795, 786, 791 and 781, respectively.

The proposed revision of the Tentative Methods of Testing Asphalt Roll-Roofing Surfaced with Fine Talc, Granular Talc or Mineral Granules; also Asphalt Shingles Surfaced with Mineral Granules, was accepted. The methods in their revised form appear on page 799.

REPORT OF SUBCOMMITTEE VIII ON ACCELERATED WEATHERING TESTS

In the previous reports[1] of cooperative tests by Subcommittee VIII on Accelerated Weathering Tests it was shown that the differences obtained in the test results were due to differences in the intensities of the alternating-current lamps and the direct-current lamps. Two methods by which the two types of arc lamps might be made to give the same results were also suggested: one by decreasing the distance between the light source and the test specimen; the other, which is the feasible one, by increasing the amperage of the alternating-current lamp.

The cooperative tests indicated that, taking the direct-current lamp operating at 12 to 14 amp. as standard, the alternating lamp would have to operate on 15 to 17 amp. in order that the two types of lamps should give similar weathering results. It was, therefore, decided that no further cooperative tests should be made until information regarding the radiant energy of the two types of lamps could be obtained. This information is now available and is reproduced below.

The following are the results of a comparison of the direct-current and alternating-current lamps showing the spectral range:[2]

	Percentage of Total Radiation to Limit of Fluorite Transmission in Infra Red (12,000 $\mu\mu$)	
Spectral Range	Direct Current Arc on 12 to 14 amp.	Alternating Current Arc, 60 cycles, 15 to 17 amp.
279 to 290 $\mu\mu$	0.6	0.8
290 to 320 $\mu\mu$	3.4	4.1
320 to 360 $\mu\mu$	5.9	6.0
360 to 480 $\mu\mu$	15.3	14.5
480 to 600 $\mu\mu$	8.9	8.0
600 to 1 400 $\mu\mu$	15.1	14.8
1400 to 4 200 $\mu\mu$	21.3	21.4
4200 to 12 000 $\mu\mu$	29.5	30.4

The intensity of the light of the arc lamps at the stated amperage is approximately 3850 foot-candle[2] as measured by a Weston illuminometer.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 511 (1931); also Vol. 32, Part I, p. 452 (1932).

[2] These determinations were made by Atlas Electric Devices Co., at the request of Subcommittee VIII.

These measurements of the spectral range and the intensities of illumination (foot-candles) show that the direct-current lamp and the alternating-current lamp are similar when their amperage is 12 to 14 amp. and 15 to 17 amp., respectively.

Similar measurements[1] of the intensity of illumination (foot-candles) of the direct-current lamp, on a plane 15 in. from the source, were made by means of a Macbeth illuminometer. These determinations showed that the intensity of the light fluctuates with the position of the flame of the arc as shown in the following table:

POSITION OF FLAME	INTENSITY OF ILLUMINATION, FOOT-CANDLES
Flame away from observer	680
Flame on side	1910
Flame toward observer	3570

To use intensity measurements for standardization of arc lamps, many readings over a long period of time should be made to obtain average results instead of single readings at a given moment as in the case of the readings given in the above table. These readings, however, do show that for uniform light the cylinders must be continuously rotated. It follows, furthermore, that panels must be alternated daily between the upper and lower rows.

Respectfully submitted on behalf of the subcommittee,

O. G. STRIETER,
Chairman.

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[1] Published through courtesy of the U. S. Bureau of Standards.

APPENDIX

PROPOSED METHOD FOR ACCELERATED WEATHERING TESTS ON BITUMINOUS MATERIALS

1. *Scope.*—This method is intended for determining the durability of bituminous substances or materials containing bitumen by producing rapid deterioration of the materials in the laboratory under conditions similar to those obtained upon outdoor exposure.

2. *Apparatus.*—The apparatus required consists of the actual weathering equipment, a trimmer to prepare the bituminous coatings and an instrument to determine the extent of the "weathering," as follows:

(*a*) *Accelerated Weathering Equipment*[1] (Fig. 1).—The actual weathering equipment shall consist of a carbon arc lamp, a cylinder, a sprinkler and a temperature control apparatus (thermo-regulator).

The carbon arc lamp shall operate on a 220-v. line, either direct or alternating current. The voltage shall be reduced by means of resistances to 140 to 145 v. and 12 to 14 amp. for direct current and to a slightly lower voltage, 135 to 140 v. with 15 to 17 amp., for alternating current. The lamp shall be equipped with an ammeter, a watt-hour meter and a voltmeter, all three instruments being connected across the arc. Solid carbon electrodes shall be used in the direct-current lamp, while in the alternating-current lamp one solid and one cored carbon electrode shall be used. The lamp globes shall be made of Corex-D glass.

A cylinder 30 in. in diameter and 15 in. in depth, equipped with slots to hold the test specimens and connected with a revolving mechanism geared to furnish one revolution in 20 minutes surrounds the lamp. The lamp and cylinder shall be suspended over a copper tank 4 in. in depth, in such a manner that it can be raised above the cylinder during the water or rain exposure period and to facilitate changing the electrodes.

For maintaining a uniform temperature during the light period the weathering apparatus shall be equipped with a thermo-regulator. By means of this thermo-regulator[2] air shall be driven through a large tube or duct ending underneath the lamp or specimens by means of a blower which in turn is driven by a motor. The motor shall be regulated by means of a thermostat placed at the surface of the specimens (15 in. from the carbon electrodes).

A refrigerator capable of maintaining a temperature of -10 F. (-23 C.) forms a separate unit.

(*b*) *Trimmer.*—The trimmer or "doctor" (Fig. 2) consists of an electrically-heated roll, equipped with thermostatic control, suspended over a stationary base. The roll can be raised or lowered by means of set-screws.

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[1] This apparatus is described in detail in the following papers: P. H. Walker and E. F. Hickson, "Accelerated Tests of Organic Protective Coatings," U. S. Bureau of Standards *Journal of Research*, Vol. 1, No. 1, p. 1 (1928); also O. G. Strieter, "Accelerated Tests of Asphalts," U. S. Bureau of Standards *Journal of Research*, Vol. 5, No. 2, p. 247 (1930).

[2] This thermo-regulator is now standard equipment of Weather-Ometer machines. For a different arrangement, see Engineering Bulletin, *Research Series No. 43*, Purdue University.

(*c*) The apparatus[1] for determining the extent of weathering (Figs. 3 and 4) shall consist of the following:

One terminal of a single 1.4-v. dry cell, *A*, shall be connected to a 1-megohm fixed resistance, *B*, thence to a galvanometer, *G*, and thence to a cell, *D*, containing a dilute electrolyte. The cell, *D*, shall be made of a copper tube fitted into a piece of bakelite tubing which acts as an insulator. A piece of maplewood dowel pin shall fit snugly into the copper tube. This wood pin acts as a "wick" to carry the electrolyte (a 0.5 per cent solution of magnesium sulfate). Copper gauze contained in the wood frame, *E*, shall be connected to the other terminal of the dry cell, *A*. A bakelite template, *F*, with ten holes about 1.6 cm. in diameter equally spaced over the panel definitely places each individual test.

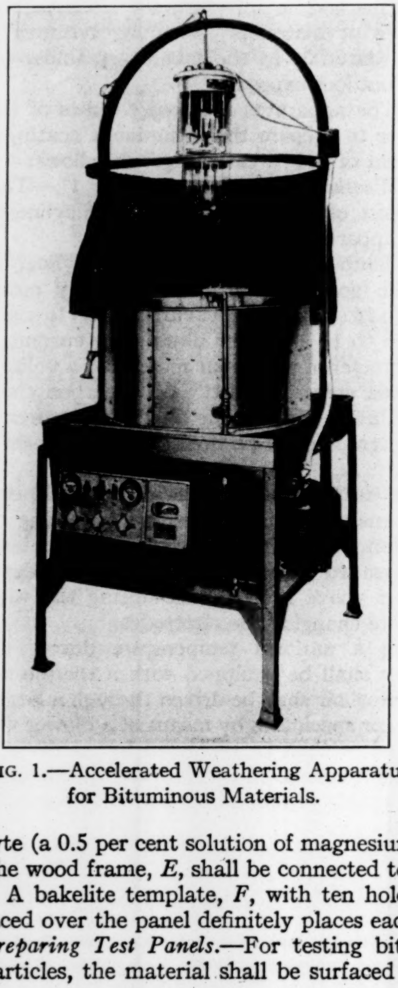

FIG. 1.—Accelerated Weathering Apparatus for Bituminous Materials.

3. *Method of Preparing Test Panels.*—For testing bituminous materials, other than finished articles, the material shall be surfaced upon an aluminum

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[1] P. H. Walker and E. F. Hickson, "Accelerated Tests of Organic Protective Coatings," U. S. Bureau of Standards *Journal of Research*, Vol. 1, No. 1, p. 1 (1928); also H. A. Gardner, "Physical and Chemical Examination of Paints, Varnishes, Lacquers and Colors," Inst. Paint and Varnish Research, Fifth edition, October, 1930, p. 428.

panel. The sample shall be melted at the lowest possible temperature in a seamless can and then poured upon the heated (130 to 160 F., 55 to 70 C.) 3 by 6 by $\frac{1}{16}$-in. aluminum panel. Just previous to pouring, the aluminum panel shall be placed on a piece of folded typewriter paper on the base of the trimmer. The paper takes up excess bituminous material and keeps the base clean. For convenience it is better to use two such papers so that one remains stationary and the other draws the panel under the trimmer, Fig. 2. The panel and the bituminous material shall then be drawn under the previously set and heated trimmer so that a bituminous film of 0.025 in. ± 0.003 in. is obtained. It may be necessary to draw the panel back and forth under the heated roll several times. The panel shall then be allowed to cool, the edges shall be cleaned and then calipered, five readings being taken lengthwise

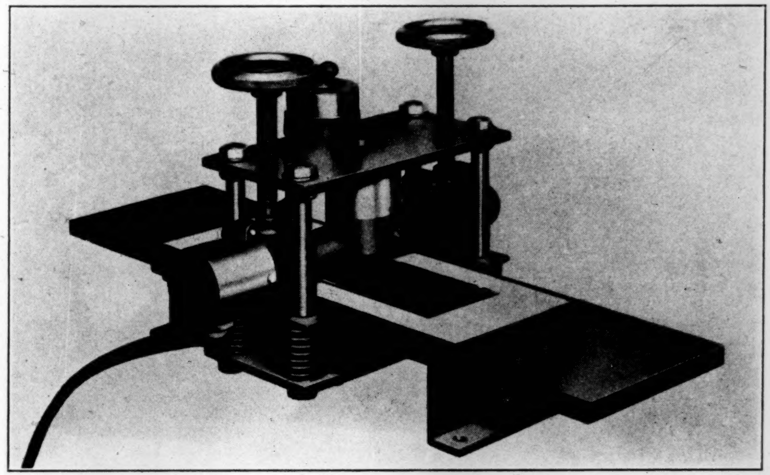

FIG. 2.—Trimmer.

It is important in all these operations that overheating of the bituminous material be avoided.

After each coating operation, the trimmer shall be wiped with cloth or paper to keep the roll clean and smooth. The temperature of the trimmer is approximately correct when paper held against it slightly browns.

4. *Test Procedure.*—The test specimens shall be subjected to a daily weathering cycle consisting of periods of exposure to cold, light, and water, the weathering cycle being as follows:

Cold exposure for a period of 1¾ hr.
Rain exposure for a period of 1 hr.
Light exposure for a period of 1½ hr.
Rain exposure for a period of 2 hr.
Light exposure for a period of 16½ hr.

For the cold exposure period the panels shall be placed on a rack in the refrigerator (previously cooled to −10 F. (−23 C.). For the rain and light exposure periods, the panels shall be placed in the holders of the cylinder. The panels shall be alternated from day to day between the upper and lower tiers of holders on the cylinder. Approximately 15 minutes are required to change from one exposure period to the other.

The temperature at the surfaces of the panels during the light exposure periods shall be about 140 F. (60 C.) as measured by placing a black bulb thermometer horizontally opposite the arc at the surface of the panels. The temperature of the water used for spraying shall be as taken from the tap. Water shall be kept in the copper tank (approximately 2 in. in depth at the start) during the light exposure period to modify the temperature and to humidify the air.

The lamp globes shall be washed daily, using a non-scratching scouring powder, and dried thoroughly.

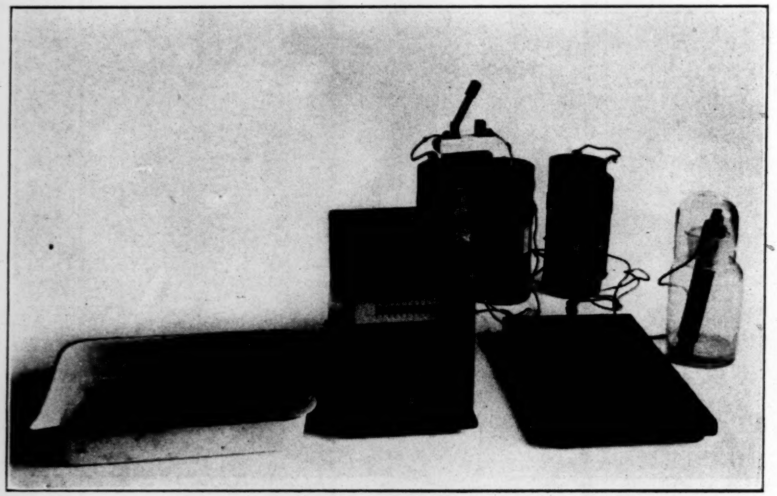

FIG. 3.—Conductivity Test Apparatus.

The electrodes shall be changed daily. At this time the metal parts of the lamp (those inclosed by the glass globe) shall be cleaned by brushing, thus removing soot and rust.

5. *Determining Extent of Weathering.*—The "conductivity test" (Figs. 3 and 4) for determining the extent of weathering shall be made as follows:

The panel shall be placed on the test surface, *E*, the aluminum side against the copper gauze, then covered with the bakelite template, *F*, and this shall be firmly clamped by spring clamps to the frame, thus pressing the panel firmly against the gauze. The wick, *D*, moistened with the electrolyte shall be brought in contact with the bituminous surface through the holes in the template, *F*. In order to insure rapid penetration a small quantity of alcohol may be added to the electrolyte. Some of the electrolyte shall be poured into the copper tube and when not in use the outer end of the wood plug shall be placed in a shallow layer of the same solution so as to keep the wood wet with the electrolyte. If cracks are present in the coating, the electrolyte will penetrate to the aluminum, closing the circuit and causing the galvanometer needle, *G*, to fluctuate. The conductivity test, when made, shall be made immediately following the completion of the 16½-hr. light period. Any degree of fluctuation of the galvanometer, *G*, shall be considered positive.

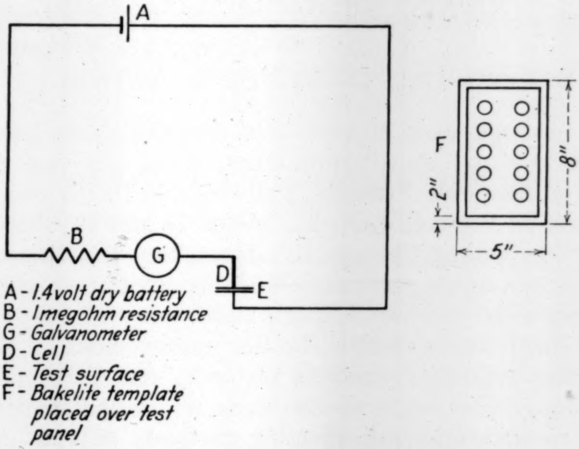
A
B
G
D
E
F
2"
8"
5"
A - 1.4 volt dry battery
B - 1 megohm resistance
G - Galvanometer
D - Cell
E - Test surface
F - Bakelite template placed over test panel

FIG. 4.—Wiring Diagram for Conductivity Test.

The weathering test shall be considered completed when six or more positive tests (out of a possible ten) are obtained. The test shall be reported as the number of weathering cycles necessary to obtain this result.

For permanent records the test specimens shall be photographed. A fingerprint camera is suitable for this purpose.

REPORT OF COMMITTEE D-9
ON
ELECTRICAL INSULATING MATERIALS

Two meetings, each of two days' duration, have been held by Committee D-9 and its subcommittees during the year as follows: At the Hotel Benjamin Franklin, Philadelphia, Pa., November 3 and 4, 1932; and at Bronxville, N. Y., March 16 and 17, 1933. A third meeting will be held at Chicago, Ill., during the annual meeting of the Society previous to the presentation of this report.

The committee has been active in the development of new methods of testing insulating materials, in the improvement of the present standard and tentative standard methods, and in the drafting of specifications. The scope of the work is covered in detail in the following recommendations affecting methods of test and in the description of the activities of the subcommittees.

Subsequent to the 1932 annual meeting, as mentioned in the annual report last year,[1] the committee presented to the Society through Committee E-10 on Standards the following three new tentative methods and revisions in three existing tentative methods. These new and revised tentative standards were accepted for publication as tentative[2] by Committee E-10 at a meeting held on August 11, 1932, and appear in the 1932 *Proceedings:*

New Tentative Methods of:

Testing Laminated Round Rods Used in Electrical Insulation (D 349 – 32 T)[3]

Testing Flexible Varnished Tubing Used for Electrical Insulation (D 350 – 32 T)[3]

Testing Pasted Mica Used in Electrical Insulation (D 352 – 32 T)[3]

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 473 (1932).

[2] In submitting these methods to Committee E-10 on Standards, the committee reported the following results of the letter ballot vote of a total of 34 ballots returned from a committee membership of 60: Tentative Methods of Testing Laminated Round Rods Used in Electrical Insulation (D 349 – 32 T), 23 affirmative and 1 negative; Tentative Methods of Testing Flexible Varnished Tubing Used for Electrical Insulation (D 350 – 32 T), 20 affirmative and 1 negative; Tentative Methods of Testing Pasted Mica Used in Electrical Insulation (D 352 – 32 T), 23 affirmative and 1 negative; Tentative Method of Testing Sheet and Tape Insulating Materials for Dielectric Strength (D 149 – 32 T), 27 affirmative and none negative; Tentative Methods of Testing Varnished Cloths and Varnished Cloth Tapes Used in Electrical Insulation (D 295 – 32 T), 23 affirmative and none negative; Tentative Methods of Testing Laminated Tubes Used in Electrical Insulation (D 348 – 32 T), 25 affirmative and none negative.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, pp. 899, 902, 911 (1932); also 1932 Book of A.S.T.M. Tentative Standards, pp. 917, 920, 929.

Revised Tentative Methods of:

Testing Sheet and Tape Insulating Materials for Dielectric Strength (D 149 – 32 T)[1]

Testing Varnished Cloths and Varnished Cloth Tapes Used in Electrical Insulation (D 295 – 32 T)[1]

Testing Laminated Tubes Used in Electrical Insulation (D 348 – 32 T)[1]

RECOMMENDATIONS AFFECTING STANDARDS

I. Proposed Tentative Standards:

Proposed Tentative Specifications for Flexible Varnished Tubing Used in Electrical Insulation.[2]—Need for a standard specification for flexible varnished tubing has made itself evident by an uneconomic multiplicity of sizes and requirements. A careful study of the requirements of the trade has led to the preparation of specifications which the committee hopes will be satisfactory to the industry, and the use of which should result in substantial simplification. The committee accordingly recommends that the proposed Tentative Specifications for Flexible Varnished Tubing Used in Electrical Insulation, appended hereto,[2] be accepted for publication as tentative.

Proposed Tentative Specifications for Black Bias-Cut Varnished Cloth Tape Used for Electrical Insulation.[3]—To fill a long-felt need for a standard specification for black bias-cut varnished cloth tape for use in insulating bus bars and cable joints and terminals, the committee has given careful study and consideration to the preparation of the present proposed specifications. Many specifications in commercial use have contributed to these and the committee hopes that the industry will find them usable and acceptable. Comments from those who use these specifications are especially desired during the coming year. The committee accordingly recommends that the proposed Tentative Specifications for Black Bias-Cut Varnished Cloth Tape Used for Electrical Insulation, appended hereto,[3] be accepted for publication as tentative.

Proposed Tentative Methods of Testing Sheet and Tape Electrical Insulation for Thickness.—In last year's report a method of adjustment and operation for a machinist's micrometer was added to the Tentative Methods of Testing Untreated Paper Used in Electrical

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, pp. 810, 886, 895 (1932); also 1932 Book of A.S.T.M. Tentative Standards, pp. 814, 898, 913.

[2] See p. 815.— ED.

[3] See p. 809.— ED.

Insulation (D 202 - 32 T)[1] as a test method for thickness, Sections 8 to 13, inclusive. This test method was also incorporated as Sections 6 to 11 in the Tentative Method of Test for Grading Natural Mica According to Size, Commercial Quality, and Thickness (D 351 - 32 T).[1] Because of the general applicability of this test method for thickness, the committee proposes that it be issued as a separate tentative method. It is accordingly recommended that Sections 8, 9, 11 and 12 of the Tentative Methods of Testing Insulating Paper (D 202 - 32 T),[1] with the addition of the following scope clause, be issued as a separate tentative method of test. The revisions of the Tentative Methods D 202 and D 351 which will be required by the acceptance of this recommendation, are given later in this report:

1. *Scope.*—These methods are intended to determine the thickness of sheet and tape insulating materials, except (*a*) rubber insulating tape which should be tested in accordance with the Tentative Specifications for Rubber Insulating Tape (A.S.T.M. Designation: D 119 - 32 T) of the American Society for Testing Materials, and (*b*) friction tape for electrical purposes which should be tested in accordance with the Tentative Specifications for Friction Tape for General Use for Electrical Purposes (A.S.T.M. Designation: D 69 - 32 T) of the American Society for Testing Materials.

II. Proposed Revision of Standard:

Standard Methods of Testing Electrical Porcelain (D 116 - 30)[2].—Experience in applying these methods to dry-process porcelain has shown that in the test for water absorption the period of immersion (100 hours) is unnecessarily long and that satisfactory results can be secured in 30 minutes. It was decided, therefore, on the recommendation of Subcommittee V on Ceramic Products (Porcelain, Glass, etc.) (L. E. Barringer, chairman), that the water absorption test should be rewritten with especial thought to use as a measure of porosity of dry-process porcelain and that the pore volume test as at present written should be used as a measure of porosity of all the more dense porcelain bodies. A suitably worded scope clause has been suggested to indicate the range of each test. The committee accordingly recommends the following revision of these methods for publication as tentative:

Sections 31 to 34, inclusive.—Change the porosity (water absorption) test from its present form, to read as follows:

POROSITY

31. *Scope.*—(*a*) In the case of relatively coarse and porous bodies, the porosity of porcelain may be indicated by the amount of water which they absorb,

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, pp. 837, 906 (1932); also 1932 Book of A.S.T.M. Tentative Standards, pp. 848, 924.

[2] 1930 Book of A.S.T.M. Standards, Part II, p. 991.

expressed as percentage (by weight) water absorption. Method A, described in Sections 32 to 34, is intended to be used for such cases and shall be used whenever the value of water absorption is 0.1 per cent or over.

(*b*) In the case of the more dense porcelain bodies, the porosity of porcelain may be indicated by the amount of gas contained in a sample of known volume, expressed as percentage (by volume) pore volume. Method B, described in Sections 35 to 40, is intended to be used for such cases and shall be used whenever the value of water absorption (Method A) is less than 0.1 per cent.

A. Water Absorption

32. *Apparatus.*—The apparatus shall consist of the following:

(*a*) A chemical balance; and

(*b*) An oven capable of maintaining a temperature of 120 C. ± 5 C. (248 F. ± 9 F.).

33. *Specimens.*—(*a*) The specimen used shall weigh from 20 to 50 g. and shall have at least 25 per cent of the surface newly fractured.

(*b*) Not less than five specimens shall be tested.

34. *Procedure.*—(*a*) Each specimen shall be dried for two hours in the oven at 120 C. (248 F.), then cooled in a desiccator to the approximate room temperature and weighed immediately.

(*b*) The specimen shall then be transferred to a beaker of briskly boiling distilled water and allowed to remain totally submerged therein for 30 minutes. It shall then be removed and quenched in distilled water at room temperature (about 20 C., 68 F.). The surface water shall be wiped off with a soft cloth and the specimen weighed immediately.

35. *Report.*—The report shall include the following:

(*a*) The dry weight of each specimen.

(*b*) The weight of each specimen after immersion.

(*c*) The percentage water absorption of each specimen.

(*d*) The average percentage water absorption of all specimens tested.

Power Factor, Dielectric Strength and Resistivity.—To provide specific reference to the available tests for these properties, the following Sections 42 and 43 are recommended for inclusion in the methods:

POWER FACTOR AND DIELECTRIC CONSTANT

42. The power factor and dielectric constant shall be determined in accordance with the Tentative Methods of Testing Electrical Insulating Materials for Power Factor and Dielectric Constant (A.S.T.M. Designation: D 150 – 32 T) of the American Society for Testing Materials.

RESISTIVITY

43. The resistivity shall be determined in accordance with the Standard Methods of Test for Resistivity of Insulating Materials (A.S.T.M. Designation: D 257) of the American Society for Testing Materials.

III. Revision of Tentative Standards:

Tentative Methods of Testing Sheet and Tape Insulating Materials for Dielectric Strength (*D 149 - 32 T*).[1]—In connection with the preparation of specifications for black varnished cloth tapes, which use these test methods, several changes in the methods have been suggested. The committee accordingly recommends that these methods be revised as follows and continued as tentative:

Section 7.—Reletter this section as Paragraph (*a*) and add a new Paragraph (*b*) reading as follows:

(*b*) The electrodes shall be so mounted as to preclude any surface burning of the tape whatever and to prevent flashovers. If flashovers occur either over the edge of the tape or from the upper electrode to an adjacent lower electrode, or if the punctures in the tape are accompanied by a burning or charring of the surface of the tape, all the voltage readings obtained in making the test will not be reliable and shall be discarded and a new specimen tested.

Section 10.—Change to read as follows by the addition of the italicized words:

10. *Unless otherwise specified*, ten tests shall be made and the average of these ten puncturing voltages shall be taken.

Section 11.—Change from its present form: namely,

11. The thickness shall be the average of ten readings taken near the points of puncture, using a ratchet micrometer graduated to 0.001 in. and having a circular foot not less than 0.24 in. nor more than 0.26 in. in diameter. In the case of tapes, the readings shall be taken along the center line of the specimen, nine of them between punctures and the tenth outside the first or last puncture.

to read as follows:

11. (*a*) The thickness shall be measured near the point of puncture with a machinist's micrometer graduated to 0.001 in. and having anvil and spindle surfaces not less than 0.24 in. and not greater than 0.26 in. in diameter.

> NOTE.—The micrometers specified in the Tentative Methods of Testing Sheet and Tape Electrical Insulation for Thickness (A.S.T.M. Designation: D 374 - 33 T) of the American Society for Testing Materials are suitable for this purpose.

(*b*) The number of thickness readings on the specimen shall be equal to the number of punctures made under Section 10. In the case of tapes, the readings shall be distributed along the center line of the specimen in such manner as to represent closely the thickness at the points of puncture.

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[1] ***Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 810 (1932); also** 1932 Book of A.S.T.M. **Tentative Standards, p. 814.**

Section 12.—Change the first paragraph to read as follows by the addition of the italicized words.

12. *Unless otherwise specified*, the report shall include the following:

Laminated Materials.—An extensive investigation of the effect of humidity on the dielectric strength of sheet materials has shown that the dielectric strength is not appreciably affected by humidities of 85 per cent or less. A water immersion test is under consideration to determine the effect of higher humidities on the dielectric strength. The committee accordingly recommends the insertion of a new Section 31, reading as follows, renumbering the present Sections 31 to 35 accordingly:

31. *Conditioning.*—Exposure to humidity has little effect on dielectric strength as long as the relative humidity is below 85 per cent. It is not necessary to condition specimens or to test them under specified relative humidities when materials are intended for use where the relative humidity does not exceed 85 per cent.

Appendix.—The increased use of narrow tapes has made it necessary to devise a tape tester which will prevent flashover when testing such tapes better than do those now described in the Appendix to these methods. A more efficient tape tester has been perfected. The committee accordingly recommends that the present Appendix to these methods be replaced by the description of the new apparatus appearing in Appendix I[1] to this report.

Tentative Methods of Testing Compounds Used for Splicing Electrical Cables and Filling Potheads (D 176 - 29 T).[2]—An important characteristic of these compounds is the variation of the electrical resistance as a function of temperature. A test method has been prepared by Subcommittee VI on Solid Filling, and Treating Compound (J. M. Wilson, chairman), to cover such measurements, containing general recommendations for the type of test cell, temperature range, handling of sample, and testing technique which laboratory tests have shown to be necessary for reliable results. The committee accordingly recommends that the test method for volume resistance-temperature characteristic and the appendix attached thereto, which appears in Appendix II[3] of this report, be added as an additional test to the present Tentative Methods D 176, as Sections 10 to 15, inclusive, and Appendix II, renumbering the present Sections 10 to 16, inclusive, as Sections 16 to 22, respectively, and renumbering the present appendix. As thus revised it is recommended that these methods be continued as tentative.

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[1] The description of the new apparatus has been incorporated in the revised Tentative Methods of Testing Sheet and Tape Insulating Materials for Dielectric Strength, see p. 828.—ED.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 751 (1929); also 1932 Book of A.S.T.M. Tentative Standards, p. 841.

[3] The test method for volume resistance - temperature characteristic has been incorporated in the revised Tentative Methods of Testing Compounds Used for Splicing Electrical Cables and Filling Potheads, see p. 818.—ED.

Tentative Methods of Testing Untreated Paper Used in Electrical Insulation (D 202 - 32 T).[1]—As mentioned earlier in this report, the preparation of a separate proposed Tentative Method of Testing Sheet and Tape Electrical Insulating Material for Thickness has removed several sections of these methods. The committee accordingly proposes the following changes in the Tentative Methods D 202 to provide a reference to the newly prepared methods, and recommends that the methods as thus revised be continued as tentative:

Sections 8 to 13, inclusive.—Delete these sections and replace by the following, renumbering the remaining sections accordingly:

8. *Apparatus.*—The thickness shall be determined in accordance with the Tentative Methods of Testing Sheet and Tape Electrical Insulation for Thickness (A.S.T.M. Designation: D 374 - 33 T) of the American Society for Testing Materials.

9. *Specimens.*—Specimens shall consist of the original samples obtained in accordance with Section 2 (*a*).

10. *Number of Measurements.*—At least five measurements of the thickness shall be taken at regular intervals across the entire width of each specimen.

11. *Report.*—The average, maximum, and minimum thicknesses obtained on each specimen shall be reported.

Tentative Methods of Testing Varnished Cloths and Varnished Cloth Tapes Used in Electrical Insulation (D 295 - 32 T).[2]—During the past year material specifications have been written based on these test methods. As a result several changes have been felt necessary. Some are for purposes of clarification, others represent actual modification of the test method and are based on sound experimental data. The committee accordingly recommends that these methods be revised as follows and continued as tentative:

Section 2 (c).—Change this section to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

(*c*) *Tape.*—At least one roll or pad shall be selected from each [100] *1000* rolls or pads in a shipment of varnished cloth tape. *The minimum number of rolls or pads selected shall be ten.*

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 837 (1932); also 1932 Book of A.S.T.M. Tentative Standards, p. 848.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 886 (1932); also 1932 Book of A.S.T.M. Tentative Standards, p. 898.

Section 3 (a).—Change the first sentence to read as follows by the addition of the italicized words:

3. (*a*) *Except for tape shipped packed in oil,* not less than two turns of cloth or six turns of tape from each roll or pad selected for sampling shall be torn off and discarded before the samples are selected.

Change Note 1 to read as follows by the addition of the italicized words and the omission of those in brackets:

NOTE 1.—Specimens of bias materials cut [in] *from* the above [manner will] *samples shall* exclude seams and jointed-selvages from the test areas.

Section 4.—Change to read as follows by the addition of the italicized words:

4. *All* specimens shall be *taken from the samples selected in accordance with Section 3 and* before testing *shall be temperature* conditioned for at least two hours in air maintained at a temperature between the limits of 20 and 30 C. (68 and 86 F.).

Section 5.—After a careful study of thickness measurements, the committee has developed a method of adjustment and operation for a machinist's type micrometer which is suitable for cloth and tape materials. It is accordingly recommended that the apparatus specified in Section 5 be deleted and replaced by the following:

5. *Apparatus.*—The thickness shall be measured with a machinist's micrometer graduated to 0.001 in. and having anvil and spindle surfaces not less than 0.24 in. nor more than 0.26 in. in diameter.

NOTE.—The micrometers specified in the Tentative Methods of Testing Sheet and Tape Electrical Insulation for Thickness (A.S.T.M. Designation: D 374 - 33 T) are suitable for this purpose.

Section 7.—Change to read as follows by the omission of the words and figures in brackets:

7. In making thickness measurements, only one layer of material shall be used [and the micrometer plunger shall be raised to a point where its lower surface is from 0.45 to 0.55 mm. (0.018 to 0.021 in.) above the surface of the specimen lying in contact with the surface of the fixed anvil. The plunger shall be dropped from this point on to the specimen without retarding its speed of descent. When the thickness is read, care shall be taken not to touch the instrument.].

Section 8.—Change Paragraphs (*a*) and (*b*) to read as follows by the addition of the italicized words and the omission of those in brackets, retaining the present note:

8. (*a*) In the case of cloths, [five readings] *ten measurements* equally spaced across the width of the specimen [and five readings, equally spaced along the length of the specimen,] shall be taken and the thickness of the cloth shall be the average of the ten measurements.

(*b*) In the case of tapes, ***unless otherwise specified*** [not more than five readings], ***ten measurements*** equally spaced along the length of each specimen shall be taken and the thickness of the tape shall be the average of the ten measurements [taken on at least two specimen lengths].

Section 11.—Change to read as follows, retaining the present note, by the addition of the italicized words and figures and the omission of the word in brackets:

11. Specimens cut from the full width cloth *or from tapes over 2.54 cm. (1 in.) in width* shall be 2.54 cm. (1 in.) in width and not less than 35.54 cm. (14 in.) in length. *For tape having a nominal width of 2.54 cm. (1 in.) or under* the [tape] specimens shall be of the original width and shall be not less than 35.54 cm. (14 in.) in length.

Section 12 (c).—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

(*c*) In the case of tapes, [ten] *one* specimen shall be cut from *each* sample selected in accordance with Section [3] *2 (c)*.

Section 14 (a).—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

14. (*a*) The tensile breaking strength *of a roll* shall be the average of the breaking loads of [the ten] *all the* specimens *from the roll.* The report shall include the average, maximum, and minimum breaking loads in kilograms or pounds together with the width of the [specimen] *specimens* and the [average] *nominal* thickness.

Section 17.—Delete this section which reads as follows:

17. (*a*) In the case of cloths, the dielectric strength shall be the average of the required number of puncturing voltages taken equally spaced along the specimen length.

(*b*) In the case of tapes, the dielectric strength shall be the average of the required number of puncturing voltages taken on at least two specimen lengths, one half the punctures being made equally spaced along each length.

Section 18.—This section covers the scope of the elongation and deformation tests and their effect on dielectric strength. The committee is recommending the deletion of the deformation test and accordingly recommends that this section be changed from its present form and renumbered to read as follows:

ELONGATION

(*In the Case of Bias-Cut Material*)

17. *Scope.*—This method is intended to determine the effect of mechanical tension on bias-cut varnished cloths and tapes. This test is not applicable to tapes of less than 1.27 cm. (0.5 in.) in nominal width.

Sections 19, 20 (a) and (b).—Renumber these as Sections 18, 19 (*a*) and (*b*), respectively, and insert the following note following Paragraph (*b*):

NOTE.—Strips of "Scotch tape" make a satisfactory method for marking the gage length on the elongation test specimens.

Section 20 (c).—Delete this section which reads as follows:

(*c*) A set of three specimens shall be used for test at each load.

Sections 21 to 24, inclusive.—Replace the present Sections 21 to 24 by the following Sections 20 and 21:

20. (*a*) *Elongation.*—A gage length, L, shall be marked on the test specimen and the specimen shall be fastened between the two clamps so that the test length is centrally located between the clamps. The gage length, L, shall be determined from the ratio:

$$\frac{L}{W} = 10$$

where W is the width of the specimen.

The clearance distance, D, between the jaws of the clamps shall be determined from the ratio:

$$\frac{D}{W} = 22$$

The test specimen shall be weighted with a specified load M (including the weight of the clamp) and at the end of 35 minutes the distance between gage lines, L_1, shall be determined and the load then removed.

The percentage elongation shall be calculated from the following formula:

$$\text{Elongation, per cent} = \frac{L_1 - L}{L} \times 100$$

where L = the original gage length, in millimeters or inches; and

L_1 = the distance between gage lines under load (maximum elongation), in millimeters or inches.

(*b*) *Dielectric Strength.*—After at least 20 minutes following the removal of the load, five puncturing voltages shall be taken within the gage length of the specimen in accordance with Method *A* for Short-Time Dielectric Strength Test as described in Sections 2 to 12, inclusive, of the Tentative Methods of Testing Sheet and Tape Insulating Materials for Dielectric Strength (A.S.T.M. Designation: D 149 – 33 T) of the American Society for Testing Materials.

21. *Report.*—The report shall include the following:

(*a*) the load in pounds per inch width of tape;
(*b*) the percentage elongation;
(*c*) the average dielectric strength in volts per mil after elongation; and
(*d*) the temperature of the room during the elongation test.

Sections 25 to 31, inclusive.—Replace the tests for resistance to oil and resistance to petrolatum by the following, renumbering the remaining sections accordingly:

RESISTANCE TO OIL

22. *Procedure.*—One specimen, 30.48 cm. (12.0 in.) in length, and not exceeding 3.81 cm. (1.5 in.) in width shall be cut from each of the selected rolls and immersed for 15 minutes in a specified oil, maintained at a temperature of from 97 to 103 C. At the end of this time the specimens shall be removed

from the oil, allowed to cool for 30 minutes to room temperature and any excess oil removed by placing between blotters without any sliding.

23. *Examination.*—The varnish film shall neither disintegrate in the oil nor flake either in the oil or on the blotter. Disintegration in the oil may be detected by examination of the used oil for "turbidness."

> NOTE.—The oil may be considered "turbid" if a sample of used oil filtered through filter paper can be distinguished from an unfiltered sample of the used oil when the two samples, in identical containers, are held in front of a diffused light.

24. *Report.*—The specimen shall be reported as passing the test when it shows no evidence of disintegration when examined in accordance with Section 23.

Tentative Methods of Test for Grading Natural Mica According to Size, Commercial Quality, and Thickness (D 351 - 32 T).[1]—As mentioned earlier in this report, a separate proposed Tentative Method of Testing Sheet and Tape Electrical Insulation for Thickness has been prepared. To avoid unnecessary repetition it has been decided to remove the description of the test for thickness in Methods D 351, replacing it with a reference to the newly prepared method. This modification is proposed by Subcommittee IX on Mica Products (M. P. Davis, chairman). The committee accordingly recommends that these methods be revised as follows and continued as tentative:

Sections 6 to 11, inclusive.—Delete these sections and replace by the following:

6. *Thickness.*—(*a*) Measurements of the thickness of mica shall be determined with a machinist's micrometer as specified in the Tentative Methods of Testing Sheet and Tape Electrical Insulation for Thickness (A.S.T.M. Designation: D 374 - 33 T) of the American Society for Testing Materials. In determining thickness of mica which must be held to close tolerance or where two or more specimens are to be measured at once, Method A shall be used. Where the maximum accuracy is not required, Method B may be used.

(*b*) Because of the abrasive nature of mica, the micrometer shall be tested frequently for conformity to the requirements specified in the Tentative Methods D 374. The anvil and spindle shall be cleaned as frequently as necessary to prevent the accumulation of mica dust on their surfaces and to preserve the accuracy of the measurements. To clean, the micrometer shall be closed lightly on a clean sheet of bond paper and the paper moved between the surfaces.

> NOTE.—Care must be exercised in moving from one measurement location to another to maintain the surfaces of the anvil and spindle parallel to the surfaces of the specimen at all times so as to avoid scratching the mica and accumulating mica dust under the micrometer surfaces which will cause false readings.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 906 (1932); also 1932 Book of A.S.T.M. Tentative Standards, p. 924.

IV. Advancement of Tentative Standard to Standard:

Tentative Methods of Test for Resistivity of Electrical Insulating Materials (D 257 – 32 T).[1]—These tentative methods, originally issued in 1926, have been twice revised and are now felt to be satisfactory. The committee accordingly recommends that they be advanced to standard.

TABLE I.—ANALYSIS OF LETTER BALLOT VOTE.

Items	Affirmative	Negative	Not Voting
I. Proposed Tentative Standards			
Tentative Specifications for Flexible Varnished Tubing Used in Electrical Insulation	24	0	20
Tentative Specifications for Black Bias-Cut Varnished Cloth Tape Used for Electrical Insulation	26	2	16
Tentative Methods of Testing Sheet and Tape Electrical Insulation for Thickness	32	0	12
II. Proposed Revision of Standard			
Methods of Testing Electrical Porcelain (D 116 – 30)	20	0	24
III. Revision of Tentative Standards			
Methods of Testing Sheet and Tape Insulating Materials for Dielectric Strength D 149 – 32 T)	31	1	12
Methods of Testing Compounds Used for Splicing Electrical Cables and Filling Potheads (D 176 – 29 T)	30	0	14
Methods of Testing Untreated Paper Used in Electrical Insulation (D 202 – 32 T)	30	0	14
Methods of Testing Varnished Cloths and Varnished Cloth Tapes Used in Electrical Insulation (D 295 - 32 T)	27	1	16
Methods of Grading Natural Mica According to Size, Commercial Quality, and Thickness (D 351 – 32 T)	21	0	23
IV. Advancement of Tentative Standard to Standard			
Methods of Test for Resistivity of Electrical Insulating Materials (D 257 - 32 T)	34	0	10
V. Advancement of Tentative Revision of Standards to Standard			
Methods of Testing Molded Materials Used for Electrical Insulation (D 48 – 30)	19	1	24
Methods of Testing Electrical Insulating Oils (D 117 - 31)	29	0	15

V. Advancement of Tentative Revision of Standards to Standard:

Standard Methods of Testing Molded Materials Used for Electrical Insulation (D 48 – 30).[2]—In the 1932 report of this committee, a tentative revision of these methods was published specifying moisture conditioning of samples for tensile (Section 4), compressive (Section 8), and flexural strength (Section 12), and also reducing the temperature variation of the water bath used in water absorption tests (Sections 22 and 24).[3] The committee now recommends that this revision be advanced to standard and incorporated in the methods.

Standard Methods of Testing Electrical Insulating Oils (D 117 – 31).[4]—The tentative revision of these methods proposed last year[5] included a steam emulsification test by reference to the Standard Method of Test for Steam Emulsification of Lubricating Oils (D 157). It is recommended that this tentative revision be advanced to standard and incorporated in the methods.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 873 (1932); also 1932 Book of A.S.T.M. Tentative Standards, p. 885.

[2] 1930 Book of A.S.T.M. Standards, Part II, p. 980.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 457 (1932).

[4] 1931 Supplement to Book of A.S.T.M. Standards, p. 104.

[5] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 459 (1932).

The above recommendations have been referred to letter ballot vote of the committee, which consists of 62 members. The analysis of the vote of the committee is given in Table I.

ACTIVITIES OF SUBCOMMITTEES

Subcommittee I on Insulating Varnishes, Paints, and Lacquers (C. F. Hanson, chairman):

Work on the effect of humidity and oven conditions on drying time and dielectric strength of varnish in the film state has been discontinued. A considerable amount of laboratory effort has been exerted on this subject but the results obtained are rather discordant. An extension of this work would involve considerable effort and expense which do not seem to be warranted at present. A test for hardness and oil resistance is still in process of development. The subcommittee acknowledges the urgent demand for this test.

Saturant Varnish.—The work started a year ago on saturant varnish is being continued actively. It has developed into a research project which promises to yield new information on this type of varnish. Data are being obtained on impregnation, internal drying, bonding strength, and dielectric strength of varnish-impregnated fabrics.

Lacs and Synthetic Resins.—Subcommittee I recently assumed the responsibility of developing tests and specifications for lacs and synthetic resins used in the electrical industry. For the present, it will confine its efforts to the development of a test method for shellac used in electrical insulation. A new section has been organized to carry on this work. The personnel of this section comprises new members who have been added to the subcommittee in order to obtain an adequate representation of the industry. Subcommittee XIII on Shellac of Committee D-1 is cooperating in this work. The program of work outlined recognizes existing test methods of European countries and aims toward an international agreement of tests for shellac used in electrical insulation.

Subcommittee II on Molded Insulating Materials (A. M. Lynn, chairman):

Subcommittee II recommends the advancement to standard of the tentative revision proposed last year in the Standard Methods of Testing Molded Materials Used for Electrical Insulation (D 48 – 30), as mentioned earlier in the report.

Specifications for Molding Powders.—The study of the principal characteristics of hot molding powders for inclusion in a standard specification has been continued and standard methods of test for sieve analysis and apparent density are completed.

Standard Molds for Test Specimens.—The effect of variations in mold design on the electrical characteristics of the standard disk specimen, specified in the Standard Methods of Testing Molded Materials Used for Electrical Insulation (D 48 – 30) was investigated by preparing and testing specimens from three molds, one of which was a so-called "positive" type, one a "flash" type with the overflow at the top of the mold, and the remaining one a "flash" type with the overflow at the bottom of the mold cavity. No significant differences could be found in the electrical characteristics of the specimens from the three types of molds and it therefore appears that it will be unnecessary to specify a standard design of mold for this specimen. Standard molds for the flexural and impact strength specimens are now being studied.

Impact Fatigue of Plastic, Molded Insulating Materials.—Impact fatigue tests have been made on three grades of wood-flour-filled phenolic resin molding compounds. These tests gave closely similar results for the impact fatigue resistance of all three compounds and showed that, in general, the materials would stand about 6000 impacts having a kinetic energy equal to 50 per cent of the static energy in foot-pounds required to break the specimen, and about 100,000 impacts having a kinetic energy equal to 33 per cent of the static breaking energy.

Subcommittee III on Plates, Tubes, and Rods (Dean Harvey, chairman):

Section A on Compressibility.—A 24-hour test for determining compressibility is being prepared using the machine developed by the Bell Telephone Laboratories, including the conditioning of the specimen and the method of applying the load. A short-time test using the Rockwell hardness tester is also being considered.

Section G on Bonding Strength.—It has not been found practicable to develop a test for bonding strength of sheets less than $\frac{3}{16}$ in. in thickness and further work has been discontinued.

Section I on Insulation Resistance.—A method of test for insulation resistance of laminated sheets is being investigated in cooperation with Subcommittee VII on Electrical Tests.

Section J on Heat Resistance.—At the request of the Technical Committee on Laminated Products of the National Electrical Manufacturers Association, a new section has been appointed to prepare methods of test for flammability and heat resistance of laminated sheets. A preliminary review of the subject has been made and a tentative program of work has been outlined.

Section K on Sheets and Plates.—A study is being made of the Tentative Methods of Testing Laminated Sheet Materials Used in Electrical Insulation (D 229 - 32 T) to extend their application to include sheet and plate insulating materials which are not laminated.

Subcommittee IV on Insulating Mineral Oils (E. A. Snyder, chairman):

As mentioned earlier in this report, the subcommittee recommends the advancement to standard of the tentative revision proposed last year in the Standard Methods of Testing Electrical Insulating Oils (D 117 - 31). Limitation of space permits but a brief outline of the results of a large amount of work and cooperative tests by Subcommittee IV, but anyone interested in more detailed information is advised to apply to the secretary of Committee D-9.

Neutralization Number.—A joint committee of members of Committee D-2 on Petroleum Products and Lubricants, and Committee D-9, under the supervision of Committee E-1 on Methods of Testing, was appointed at the request of Committee D-2 to review thoroughly the work done by both committees on this problem and both agreed that the Tentative Method of Test for Neutralization Number of Petroleum Products and Lubricants (D 188 - 27 T),[1] developed by Committee D-2, was not yet satisfactory to be advanced to standard because of the following reasons:

(*a*) Titration to color is difficult, if not impossible on dark oils.

(*b*) Values reported for "used" oils are non-concordant and are widely different from those obtained by other methods.

(*c*) The phenolphthalein indicator, now prescribed, appears to give particularly discordant results with either moderately dark or slightly used oils.

(*d*) It is thought that, since the test is carried out upon the water-alcohol layer with whatever proportion or kinds of acidic bodies may have been extracted from the oil, variable or partial solubilities may affect the result.

(*e*) There seem to be some indications that the reactions are progressive in character, so that the results might vary with the length of time taken for the titration.

(*f*) Disturbing factors may be present, such as emulsification, partial saponification or hydrolysis.

(*g*) Color blindness may cause discrepancies between different observers.

The joint committee agreed, however, that the Tentative Method D 188 - 27 T has the advantage of being simple, requires inexpensive apparatus, little time to run, and seems to be accurate when applied to new or light colored oils. The committee also agreed that the electrometric methods[2] developed by Committee D-9 have the disadvantage of greater cost for the apparatus and longer time required for test, but seem to be free from the other objections cited above.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 27, Part I, p. 927 (1927); also 1932 Book of A.S.T.M. Tentative Standards, p. 578.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 534 (1931).

It was also agreed first to try to improve Method D 188 - 27 T through a study of indicators and variations in test procedure, and second, to attempt to cheapen the electrometric apparatus and simplify its use with the hope of eliminating some of the objections at present offered against this type of test. The committee hopes to have enough work performed during the coming year to come to a definite conclusion on a tentative method for trial.

Sludge Test.—At the June, 1932, meeting of Committee D-9, Subcommittee IV presented the results of a large amount of cooperative work performed during the year on the development of a sludge accumulation test. Ten individual laboratories cooperated in the testing of four samples of oil. The apparatus used in the cooperative tests was the life test apparatus described in the 1927 report of Committee D-9,[1] with modifications in the manner of holding individual samples in test tubes which are in turn placed in the 500-ml. beaker containing transformer oil, which acts as an oil bath to heat the test tubes containing the samples. Samples were removed at intervals of 15, 20, 25, 35, 45, and 55 days and amount of sludge determined. All these tests were run in duplicate by the various laboratories and the results averaged. The data were then averaged and analyzed and the following conclusions reached:

(*a*) That while a short-time sludge run of 25 to 35 days would differentiate a very poor sludging oil, it was necessary to run the oxidation over 45 to 55 days before a clear separation could be made of oils such as might be sold commercially for transformer use.

(*b*) That up to the 35-day interval there was no agreement between laboratories as to the proper rating of the oils but that at intervals of 45- to 55-day periods all laboratories agreed on the proper rating of the oils.

(*c*) That the test as outlined needed modification either in the method of oxidizing the oil or in the method of determining the sludge in order to obtain greater reliability of checkable results by different laboratories, because although the laboratories rated the oils identically at 45- and 55-day intervals, there was quite a large variation in actual values of sludge reported by the different laboratories at these intervals.

(*d*) That in the attempt to determine the character of the sludge formed by its behavior to various solvents, the results obtained indicated no agreement and it was also decided that a study of the type of sludge formed was a problem entirely different from the other problems involved in developing a method of determining the amount of sludge obtained and that it should be eliminated from present consideration.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 27, Part I, p. 541 (1927).

(*e*) That the chief objections to this modified test procedure employing the life test oven, were the long time required to make the test and certain inaccuracies in the amount of sludge obtained by different operators which could possibly be eliminated by refinement of the test.

As a result of the investigation the section modified in a number of details the original procedure and new samples have been sent out for cooperative tests by the ten participating laboratories. Also, in order to determine the possibility of shortening the time of the test, a series of tests will be run with these same samples employing a copper catalyst in the test tube.

It is anticipated that by the end of the year sufficient test data may have been obtained to justify the establishment of a tentative test method.

Short-Time Sludge Tests.—The section working on the development of a short-time sludge test which can be used for checking shipments of the same grade of oil from a known source but which might not be suitable for determining the comparative value of transformer oils obtained from various sources has developed a modification of the Sligh test which seems to give fairly accurate and reproducible results.

One of the chief objections to the Sligh test has been the danger involved in operating the test and the chairman of this section has developed an aluminum block oven which, if successful, will do away with practically all of the explosion hazard of the test. In this oven the Sligh apparatus is placed in the cavity of an aluminum block which is electrically heated by resistance elements. There is no oil bath and in case of explosion, there would be no danger of spattering the operator with burning oil. Furthermore, as the explosion force would be upward, with the use of suitable screens practically all danger of flying glass could be eliminated. It is anticipated that with the coming year a tentative method may be prepared for submission to the Society.

Circuit Breaker Oils.—During the year the section studying this particular problem investigated the desirability of developing a method for measuring the viscosity of circuit breaker oils at low temperatures, and a joint committee composed of members of Committee D-9 and Committee D-2 thoroughly investigated the necessity and desirability of formulating such a test method by taking the matter up directly with a large number of manufacturers and users of circuit breakers. As a result of this investigation it was finally decided that because of the apparent small demand for a method of getting accurate measurements of viscosities at low temperatures and the cost of such an investigation if undertaken, and the ease of getting sufficiently reliable low-temperature data by extrapolation from the A.S.T.M. Viscosity-Temperature Chart[1] developed by Committee D-2, that the committee go on record as favoring the use of this D-2 chart as a source of obtaining low-temperature viscosity data for switch oils.

Subcommittee VII on Electrical Tests (E. S. Lee, chairman):

The completed work for the year had resulted in the recommendation for advancement to standard of the Tentative Methods of Test for Resistivity of Insulating Materials (D 257 - 32 T), as proposed earlier in this report.

Arrangements have been completed whereby Committee D-9 becomes joint sponsor with Committee D-16 on Slate for the Tentative Methods of Test for Determining the Electrical Insulating Qualities of Slate (D 273 - 27 T). The activities for Committee D-9 have been assigned to Subcommittee VII, Section E, acting jointly with a group from Committee D-16. Section E is investigating the available methods for electrical quality, and will study impact testing of slate.

Subcommittee VIII on Insulating Papers and Fabrics (Treated and Untreated) (R. W. Chadbourn, chairman):

During the year Subcommittee VIII has completed extensive changes in the Tentative Methods of Testing Varnished Cloths and Varnished Cloth Tapes Used in Electrical Insulation (D 295 - 32 T), slight modifications in Tentative Methods of Testing Sheet and Tape Insulating Materials for Dielectric Strength (D 149 - 32 T), and a tentative method of measuring thickness. The latter comprises the apparatus and procedure previously included in Tentative Methods of Testing Untreated Paper Used in Electrical Insulation (D 202 - 32 T). The subcommittee also developed the proposed Tentative Specifications for Black Bias-Cut Varnished Cloth Tape and Tentative Specifications for Flexible Varnished Tubing, appended hereto.[2] These recommendations are referred to in detail earlier in this report.

Progress has been made along several other lines of investigation, as follows:

Insulating Paper.—Considerable study has been made of the Nullpoint electrometric method and the Kohler-Hall method of determining acidity. The problem of titration seems to have been satisfactorily solved, but it appears that considerable attention must be given to the method of preparing the paper extract. Particular care must be taken to prevent hydrolysis of the cellulose. Laboratory investigation of this problem is under way.

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[1] This refers to the Tentative Standard Viscosity-Temperature Chart for Liquid Petroleum Products (D 341 - 32 T), *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 772 (1932); also 1933 Book of A.S.T.M. Tentative Standards, p. 576.

[2] See pp. 809 and 815.—ED.

A comparison is being made of the paper testing methods of the Technical Association of the Pulp and Paper Industry and those of the A.S.T.M. with a view to reaching more complete agreement between the methods of the two societies.

This report has been submitted to letter ballot of the committee, which consists of 62 members; 44 members returned their ballots, of whom 38 have voted affirmatively and none negatively.

Respectfully submitted on behalf of the committee,

H. L. CURTIS,
Chairman.

J. A. SCOTT,
Secretary.

EDITORIAL NOTE

The proposed Tentative Specifications for Flexible Varnished Tubing Used in Electrical Insulation, for Black Bias-Cut Varnished Cloth Tape Used for Electrical Insulation and the Tentative Methods of Testing Sheet and Tape Electrical Insulation for Thickness were accepted for publication as tentative and appear on pages 815, 809 and 860, respectively.

The proposed tentative revision of the Standard Methods of Testing Electrical Porcelain was accepted for publication as tentative and appears on page 1048.

The proposed revisions of the Tentative Methods of Testing Sheet and Tape Insulating Materials for Dielectric Strength, Testing Compounds Used for Splicing Electrical Cables and Filling Potheads, Testing Untreated Paper Used in Electrical Insulation, Testing Varnished Cloths and Varnished Cloth Tapes Used in Electrical Insulation, and Grading Natural Mica According to Size, Commercial Quality and Thickness were accepted. The methods as revised appear on pages 828, 818, 839, 864 and 837, respectively.

The Tentative Methods of Test for Resistivity of Electrical Insulating Materials were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1933, and appear in the 1933 Book of A.S.T.M. Standards, Part II, page 1107.

The tentative revisions of the Standard Methods of Testing Molded Materials Used for Electrical Insulation and Methods of Testing Electrical Insulating Oils were approved for reference to letter ballot of the Society for advancement to standard. The methods in their revised form appear in the 1933 Book of A.S.T.M. Standards, Part II, pages 1097 and 1087, respectively.

REPORT OF COMMITTEE D-11

ON

RUBBER PRODUCTS

Committee D-11 on Rubber Products has held no meeting since the 1932 annual meeting of the Society. At the last meeting the committee voted to omit the usual fall meeting because of adverse business conditions and the fact that the work before the committee could be handled satisfactorily by correspondence. The spring meeting was cancelled because of the bank holiday and the very unsatisfactory conditions which prevailed in the rubber industry. In spite of this the work of the committee has gone forward and definite progress has been made. A meeting of the committee will be held prior to the presentation of this report to the Society when the report will be reviewed and other matters considered.

RECOMMENDATIONS AFFECTING STANDARDS

Withdrawal of Standards:

The committee stated in its annual report for 1932[1] that it was the intention to recommend the withdrawal of certain specifications for several types of hose upon the completion of two proposed tentative methods of test, one for wrapped hose and one for braided hose. The basis for this action was stated to be that the present A.S.T.M. specifications and methods of test relating to hose, with the exception of those for cotton rubber-lined fire hose (D 296 – 31 T), are not widely used for reasons which were enumerated. The two new methods of test have been completed and circulated in the committee. Since the committee has not met during the year it will be necessary for these to be considered by the committee at its meeting during the annual meeting and the methods subsequently presented to the Society through Committee E-10 on Standards. Pending this action, however, the committee recommends at this time that the following three standard specifications and one tentative specification be withdrawn to be replaced by the proposed methods of test for wrapped hose and for braided hose, referred to in detail later in this report, when accepted for publication as tentative:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 478 (1932).

Standard Specifications for Wrapped Air Hose for Use with Pneumatic Tools (D 46 – 24);[1]

Standard Specifications for Braided Air Hose for Use with Pneumatic Tools (D 60 – 24);[2]

Standard Specifications for Wrapped Cold Water Hose (D 177 – 24);[3]

Tentative Specifications for Steam Hose (D 54 – 31 T).[4]

The above recommendations have been submitted to letter ballot of the committee, which consists of 76 members, with the following results:

Item	Affirmative	Negative	Not Voting
I. WITHDRAWAL OF STANDARDS AND TENTATIVE STANDARD			
Standard Specifications for Wrapped Air Hose for Use with Pneumatic Tools (D 46 – 24)	23	0	13
Standard Specifications for Braided Air Hose for Use with Pneumatic Tools (D 60 – 24)	23	0	13
Standard Specifications for Wrapped Cold Water Hose (D 177 – 24)	23	0	13
Tentative Specifications for Steam Hose (D 54 – 31 T)	23	0	13

Proposed Tentative Standards:

The following three new tentative methods of test have been completed and will be presented to Committee D-11 at a meeting to be held during the annual meeting and, if subsequently approved by letter ballot of the committee, will be submitted to the Society during the summer through Committee E-10 on Standards for publication as tentative:[5]

Proposed Tentative Methods of Testing Rubber Belting Used for Power Transmission.—The Standard Specifications for Rubber Belting for Power Transmission (D 53 – 24) were withdrawn in 1928 and at that time it was stated that they would be replaced with standard methods of test and a classification of the various types of transmission belting. The present proposed methods have been prepared in partial fulfilment of this promise. They are in substantial agreement with the methods which are acceptable to the Specifications Committee of the Rubber Manufacturers' Association.

Proposed Tentative Methods for Testing Wrapped Hose and Proposed Tentative Methods for Testing Braided Hose.—These methods of test relating to hose will be offered by the committee to the Society subsequent to the annual meeting in accordance with its policy of standardizing methods of test used for rubber products rather than sponsoring detailed product specifications of the materials type. It is felt that test methods for evaluating rubber products require further standardization before satisfactory product specifications can be prepared. It is the intention so far as possible to develop and include tests of the performance type. The present proposed methods are in general agreement with similar methods which have been approved by the Specifications Committee of the Rubber Manufacturers' Association and the committee believes that these should be accepted by the Society as tentative even though they may undergo further revisions through the introduction of new performance tests.

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 1012.

[2] *Ibid.*, p. 1016.

[3] *Ibid.*, p. 1020.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 921 (1931); also 1932 Book of A.S.T.M. Tentative Standards, p. 952.

[5] The methods were accepted for publication as tentative and appear on pp. 904, 909 and 915, respectively. See Editorial Note, p. 411.—ED.

Revision of Tentative Standards:

The committee has completed and proposes to submit to the Society during the summer through Committee E-10 on Standards revisions in the following two tentative specifications:[1]

Tentative Specifications for Insulated Wire and Cable: 30 per cent Hevea Rubber (D 27 - 31 T)[2]

Tentative Specifications for Insulated Wire and Cable: Performance Rubber Compound (D 353 - 32 T).[3]

These revisions include a new Section on Cotton Braids which is an improvement and will replace the existing section on braids, the substitution of the former table on width and over-lap of rubber-filled cable tape which appeared in the specifications as issued in 1928, in place of the table adopted in 1932, a rearrangement of the material between the two specifications and a number of other minor changes. These revisions have been very carefully and thoroughly studied within the committee and are being proposed so as to put these specifications in most convenient form and in accord with the best and most economical manufacturing practice.

ACTIVITIES OF SUBCOMMITTEES

Two new subcommittees of Committee D-11 are being formed. The first of these is a Subcommittee on Adhesion Testing for Rubber Products under the chairmanship of Mr. J. J. Allen. Its immediate assignment is to develop standard methods of test for measuring the adhesive strength of rubber to metal. This problem is of particular importance to the rubber and automotive industries and the subcommittee is an outgrowth of the former Section on Adhesion Testing of Subcommittee XVII on Rubber Products for the Absorption of Vibration. The second subcommittee is on Tests for Volume Increase of Rubber in Liquids and is under the chairmanship of Mr. O. M. Hayden. Its immediate problem is concerned with the development of suitable tests for comparing the swelling properties of rubber compounds which are to be subjected to the action of oils or various solvents.

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[1] The revisions were accepted and the revised specifications appear on pp. 871 and 894. See Editorial Note, p. 411.—ED.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 926 (1931); also 1932 Book of A.S.T.M. Tentative Standards, p. 960.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 916 (1932); also 1932 Book of A.S.T.M. Tentative Standards, p. 977.

Mr. G. S. Haslam has been appointed chairman of Subcommittee XIV on Abrasion Tests for Rubber Products succeeding Mr. H. A. Depew.

Subcommittee I on Mechanical Rubber Hose (E. G. Kimmich, chairman).—Subcommittee I is continuing the investigation of new performance tests which may be suitable for inclusion in the recently completed methods of test for wrapped hose and for braided hose referred to earlier in this report. Particular attention is being given to dynamic tests involving flexing of hose while under pressure. Tests of this type are in use in many laboratories but, as yet, there is little standardization and the results are more or less qualitative which renders exact duplication for specification purposes extremely difficult.

Subcommittee V on Insulated Wire and Cable (C. B. Martin, chairman).—This subcommittee was the only section of Committee D-11 which met during the Spring Group Meeting of A.S.T.M. Committees in New York City in March, 1933. It has also actively carried on its work during the year through meetings of its sections and by correspondence. Important new work has been undertaken in the development of standard tests for rubber insulating compounds designed to resist the action of (*a*) acids and alkalies, (*b*) oil and (*c*) corona. For this work together with that now before the subcommittee it has been decided to divide the subcommittee into the three following sections:

Section 1, under the chairmanship of Mr. R. A. Schatzel, to study cotton braids, cable tape, rubber insulation, resistant to acids and alkalies, and rubber insulation resistant to oil.

Section 2, under the chairmanship of Mr. C. R. Boggs, to study rubber insulation resistant to corona.

Section 3, under the chairmanship of Mr. J. W. Zink, to study braid saturants and finishes.

Subcommittee X on Physical Testing of Rubber Products (A. W. Carpenter, chairman).—Since the work of Committee D-11 is being directed to standardization of test methods rather than to preparation of product specifications, the organization of its various subcommittees is more effective when the subcommittees are classified according to various types of tests. The field of Subcommittee X has, therefore, been appropriated to some extent by other subcommittees. It now appears that Subcommittee X can best serve as a coordinating committee on methods of test rather than as a committee on the development of methods for physical testing. A very useful field of activity for this subcommittee will be the preparation of a collection of standard methods of tests for rubber products in the form of a manual similar to the pamphlets which have been prepared by Committees D-2 on Petroleum Products and Lubricants and D-9 on Electrical Insulating Materials. There is a real need for such a pamphlet for use by consumers of rubber products as well as manufacturers, and standardization will be greatly advanced by this means. Owing to the press of other duties the present chairman of the subcommittee has resigned and Mr. H. M. Frecker has been appointed to serve as chairman.

Subcommittee XV on Life Tests for Rubber Products (R. A. Schatzel, chairman).—Subcommittee XV has completed a comparative test program using a single compound with unaged specimens cured in a single laboratory but tested in thirteen cooperating laboratories. This test program followed a previous extensive series of aging tests which were started by the subcommittee in 1928. The results of the earlier tests are being studied by a section of the subcommittee as reported last year,[1] but early in the consideration of these results it became evident that considerable variation existed between the various laboratories in the stress-strain results obtained with what were supposed to be identical samples. It was therefore necessary, since the aging results are measured in terms of change in stress-strain properties, to ascertain what variations might be expected between various laboratories in the determination of stress-strain properties of unaged samples. This is in effect a calibration of the various laboratories and the test method used. For this purpose the present series of tests were designed and carried out. Since the report of the subcommittee furnishes valuable information concerning the reliability of the standard test for the stress-strain relation of rubber, which is of great importance to all who are concerned with the testing of rubber, the complete report is appended hereto. This report of the subcommittee will be supplemented at a later date with a summary and analysis of the results of the previous work on aging tests in order to present a comprehensive view of the status of aging tests for rubber products.

Subcommittee XVII on Rubber Products for Absorbing Vibration.—In evaluating rubber compounds which are to be used under compressive stresses for purposes of vibration absorption the measurement of the resistance of the rubber to permanent distortion is of importance. Obviously, a rubber compound which retains its resilience and does not permanently distort to any appreciable degree under the conditions and during the period of normal service life is most suitable for vibration absorption. Subcommittee XVII on Rubber

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 480 (1932).

Products for Absorbing Vibration has given its attention for some years past to the development of a suitable method for the measurement of this property of rubber and to the development of apparatus for carrying out the test. In the early discussions, the property of rubber whereby permanent distortion results from compressive loads was called "cold flow." In general, however, tests of this property are conducted at temperatures above normal in order to accelerate them. The committee, therefore, feels that the term "compression-set" is preferable, especially since actual low-temperature tests of related properties are not infrequent.

A survey was made of the automotive and rubber industries for the purpose of assembling information concerning the various methods and equipment used in measuring this property. Many variations were found to exist but, in general, the methods could be classified as follows:

1. Measuring the distortion after cutting a square or circular disk from the rubber part under test and placing it at a given temperature for a specified time, either under constant compression, or under constant deflection.

2. Measuring the distortion after forcing a metal disk or washer into the rubber part under a constant pressure for a given time at a specified temperature.

Comparative tests were next made of the various methods with seven different laboratories cooperating. The results showed wide variations indicating that greater standardization than existed was necessary in the method of preparing the samples, the method of conducting the test and in the equipment used. The subcommittee then outlined the following program: (1) develop a satisfactory standard test apparatus; (2) repeat the comparative flow tests when the apparatus is developed; and (3) develop specifications from the results covering apparatus and method of test.

As a first step in this program the subcommittee collected detailed information concerning the different types of apparatus actually in use which was then furnished, together with suggested specifications, to several instrument makers who cooperated with the subcommittee. Only one of the instrument makers, the Tinius Olsen Testing Machine Co., has continued working with the subcommittee to the point of developing and submitting proposed standard test apparatus.

While this apparatus was being developed, a certain amount of standardization of the test method has occurred within the automotive industry and the method used by the laboratories of the Chrysler Corporation has found quite general acceptance, replacing some of the earlier methods. The test has been carefully studied and reported in the technical literature[1] and is now frequently found in purchase specifications for rubber parts. In practice, minor variations still occur which lead to argument and disagreement so that further standardization is desirable.

The subcommittee has considered a proposed method of test for compression-set of rubber used for vibration absorption which covers both the apparatus and the test but is not yet ready to present this to the Society.

This report has been submitted to letter ballot of the committee which consists of 76 members; 36 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

H. A. DEPEW,
Chairman.

ARTHUR W. CARPENTER,
Secretary.

EDITORIAL NOTE

The withdrawal of the Standard Specifications for Wrapped Air Hose for Use with Pneumatic Tools, for Braided Air Hose for Use with Pneumatic Tools, for Wrapped Cold Water Hose and Tentative Specifications for Steam Hose was approved.

Recommendations to Committee E-10 on Standards.—The proposed Tentative Methods of Testing Rubber Belting Used for Power Transmission, Methods of Test for Rubber Hose, Braided Construction and for Rubber Hose, Wrapped Construction, referred to in the report, were subsequently accepted for publication as tentative on August 16, 1933, by Committee E-10 on Standards and appear on pages 904, 909 and 915, respectively.

Revisions of the Tentative Specifications for Insulated Wire and Cable: 30 per cent Hevea Rubber and for Insulated Wire and Cable: Performance Rubber Compound, referred to in the report, were accepted on August 16, 1933, by Committee E-10 on Standards. The specifications in their revised form appear on pages 871 and 894, respectively.

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[1] F. D. Abbott, *Industrial and Engineering Chemistry*, Second Analytical Edition, p. 145 (1930).

REPORT OF SUBCOMMITTEE XV ON LIFE TESTS FOR RUBBER PRODUCTS

A series of physical tests made at 13 cooperative laboratories on a single compound with unaged specimens cured in a single laboratory has been carried out under the jurisdiction of Subcommittee XV in order to explain or determine the cause of wide variations in results obtained in a previous extensive series of aging tests which were undertaken in 1928 by the subcommittee.

Program:

The program decided on was as follows:

1. Tests were run on one stock of the following formula:

Ingredients	Parts by Weight
Smoked sheets	100.0
Zinc oxide	20.0
Sulfur	3.0
Di-ortho-tolylguanidine (D.O.T.G.)	0.75

2. The cure selected from a series of cures was 40 minutes at 287 F.

3. The test slabs were prepared in a single laboratory in accordance with the standard procedure of the American Chemical Society.[1]

4. Each of the 13 cooperating laboratories received a set of dumb-bell specimens already died out for test from a test slab and an undied slab.

5. The standard American Chemical Society die for the dumb-bell type test specimen was to be used. When dies other than the standard A.C.S. die were used these have been recorded.

6. Each laboratory tested and reported separately results on the died and undied specimens. All five strips were tested and an average made in accordance with the A.C.S. procedure.

7. Complete stress-strain data were obtained at 100 per cent elongation increments.

Data:

The data obtained in these cooperative tests are given in the accompanying Tables I, II and III.

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[1] *Rubber Chemistry and Technology*, Vol. 3, p. 179 (1930); also *The Rubber Age*, Vol. 26, p. 429 (1930).

Comments on the Test:

1. E. I. duPont de Nemours and Co. cured the sheets and made their tests three days after testing. They show a higher elongation than any one else, and a correspondingly lower modulus.

2. Four of the thirteen laboratories used dies other than the standard A.C.S. die.

3. The temperature of testing varied from 68 to 85 F. (20 to 29 C.).

4. With the exception of the original tests by the duPont laboratory, the other twelve laboratories made their tests within a month of each other.

5. Reported relative humidity ranged from 43 to 80 per cent.

TABLE I.—TESTING CONDITIONS IN COOPERATING LABORATORIES FOR COMPARATIVE TESTS OF RUBBER.

COOPERATING LABORATORY	DATE OF TESTING	TEMPERATURE OF TESTING, DEG. FAHR.	RELATIVE HUMIDITY, PER CENT	TYPE OF DIE
Goodyear Tire and Rubber Co.	Sept. 8, 1932	84	..	Special
General Cable Corp.	Sept. 21, 1932	76	..	A.C.S.
E. I. duPont de Nemours and Co.	July 25, 1932	..	..	A.C.S.
American Zinc Sales Co.	Sept. 29, 1932	81	45	A.C.S.
B. F. Goodrich Co.	Sept. 14, 1932	85	45	A.C.S.
St. Joseph Lead Co.	Sept. 16, 1932	82	45	A.C.S.
U. S. Bureau of Standards	Sept. 7, 1932	82	..	Special
Firestone Tire and Rubber Co.	Sept. 20, 1932	78	43	A.C.S.
Fisk Rubber Co.	Sept. 13, 1932	70	65	Special
Bell Telephone Labs., Inc.	Sept. 22, 1932	81	48	A.C.S.
Dunlop Tire and Rubber Corp. of America	Sept. 21, 1932	84	56	Special
United States Rubber Co.	Oct. 5, 1932	80	68	A.C.S.
Okonite Co.	Oct. 3, 1932	68	80	A.C.S.

6. Two laboratories reported that difficulty was experienced in obtaining breaks within the gage marks.

7. Variations in modulus were most apparent at low elongations and at 700 per cent elongation.

8. With only two exceptions, the undied samples gave higher results than the died samples.

9. The average tensile strength of this stock as reported by the 13 laboratories checks within 50 lb. per sq. in. of stock No. 1 of the original investigation. Modulus of stock No. 1 at 400 per cent elongation on either cure, or on the average, also checks very closely with the modulus found here. The two stocks differ slightly in the zinc content.

Conclusions:

In designing this test two checks are provided. The first is a check of the influence of die on results secured. This will be evident by the variation in results obtained on died as against undied samples. The second is more difficult to evaluate and is a check on agreement of actual values obtained between laboratories when following a standard test method. In this, many quantities not measurable enter, such as testing machines, test conditions and the personal equation of the operator.

TABLE II.—STRESS-STRAIN DATA OBTAINED BY COOPERATING LABORATORIES IN COMPARATIVE TESTS OF RUBBER.

Percentage Elongation	100	200	300	400	500	600	700	Tensile Strength, lb. per sq. in.	Ultimate Elongation in 1 in., per cent
RESULTS ON SIMILAR SPECIMENS CUT WITH AMERICAN CHEMICAL SOCIETY DIE AT ONE LABORATORY									
	STRESS, LB. PER SQ. IN.								
Goodyear Tire and Rubber Co	101	187	307	507	918	1830	3195	3400	712
General Cable Corp	91	179	306	499	962	1923	3422	3563	714
E. I. duPont de Nemours and Co	...	...	250	375	775	1625	2975	3725	760
American Zinc Sales Co	154	272	389	590	1066	1950	3250	3506	705
B. F. Goodrich Co	68	140	260	509	930	1870	3324	3548	712
St. Joseph Lead Co	70	150	300	510	1100	2265	....	3232	659
U. S. Bureau of Standards	75	165	282	476	915	1885	3385	3490	710
Firestone Tire and Rubber Co	70	165	270	445	870	1770	3355	3425	705
Fisk Rubber Co	42	175	283	575	1142	2283	....	3792	682
Bell Telephone Labs., Inc	...	110	195	375	755	1705	....	3400	690
Dunlop Tire and Rubber Corp. of America	20	72	189	395	811	1814	3286	3320	702
United States Rubber Co	79	192	324	505	969	1992	....	2950[a]	680
Okonite Co	101	159	257	449	749	1430	2864	3465	728
Average	77	164	279	480	935	1909	2854	3490	703
RESULTS ON SIMILAR TEST SLABS, EACH LABORATORY CUTTING OWN SPECIMENS									
	STRESS, LB. PER SQ. IN.								
Goodyear Tire and Rubber Co	105	199	318	523	974	2000	3470	3470	700
General Cable Corp	92	177	302	506	952	1837	2845	3606	746
E. I. duPont de Nemours and Co	...	...	250	375	775	1625	2975	3725	760
American Zinc Sales Co	181	310	434	661	1228	2233	....	3322	675
B. F. Goodrich Co	61	163	270	514	962	1975	3400	3531	702
St. Joseph Lead Co	70	150	300	540	1125	2300	....	3360	658
U. S. Bureau of Standards	87	169	290	488	943	1970	3540	3760	715
Firestone Tire and Rubber Co	75	170	275	470	930	1915	3590	3690	710
Fisk Rubber Co	42	133	262	517	1108	2308	....	3325	657
Bell Telephone Labs., Inc	...	125	220	385	795	1775	....	3330	690
Dunlop Tire and Rubber Corp. of America	41	110	223	408	853	1882	3444	3730	715
United States Rubber Co	95	204	334	536	1075	2218	....	3320	680
Okonite Co	103	154	247	472	892	1722	2928	3520	722
Average	85	174	290	494	977	2003	3323	3514	701

[a] Result of one test only.

1. *Variation in Ultimate Tensile Strength.*—A study of the data seems to justify the general conclusions as given in the following Paragraphs (*a*) to (*e*), inclusive, referring to died specimens *versus* undied specimens. Paragraph (*f*) refers to the results of the individual laboratory compared to the average tensile strength of all laboratories:

(*a*) The average variation in individual laboratories in the checking of died as against undied samples is 5.8 per cent.

(*b*) The results from five of the twelve laboratories checking died as against undied samples check within 2 per cent.

(*c*) Seven of the twelve laboratories get results checking the died *versus* the undied samples within 6 per cent.

(*d*) Nine laboratories check within 8 per cent and three laboratories report values varying over 10 per cent.

(*e*) Of the five laboratories which do not check within 6 per cent, three use special dies and therefore at least a part of the wider discrepancy may be attributed to die shape. Another of these laboratories reports difficulty in making the test. Numerous jaw breaks were experienced with the result that only one value is considered in the tensile strength. This result may properly be disregarded and therefore there is only one laboratory using standard die and not checking within 6 per cent.

TABLE III.—SUMMARY—AVERAGES OF STRESS-STRAIN DATA FOR BOTH DIED AND UNDIED SAMPLES (TABLE II).

Percentage Elongation	100	200	300	400	500	600	700	Tensile Strength, lb. per sq. in.	Ultimate Elongation in 1 in., per cent
	AVERAGE STRESS, LB. PER SQ. IN.								
Goodyear Tire and Rubber Co	103	193	313	515	946	1915	3333	3435	706
General Cable Corp	92	178	304	503	957	1880	3134	3585	730
E. I. duPont de Nemours and Co	...	...	250	375	775	1625	2975	3725	760
American Zinc Sales Co	168	291	412	626	1147	2092	3250[a]	3414	690
B. F. Goodrich Co	65	152	265	512	946	1923	3362	3540	710
St. Joseph Lead Co	70	150	300	525	1113	2283	....	3296	659
U. S. Bureau of Standards	81	167	286	482	929	1928	3463	3625	713
Firestone Tire and Rubber Co	73	168	273	458	900	1843	3473	3558	708
Fisk Rubber Co	42	154	273	546	1125	2296	....	3559	670
Bell Telephone Labs., Inc.	...	118	208	380	775	1740	....	3365	690
Dunlop Tire and Rubber Corp. of America	31	91	206	402	832	1848	3365	3525	709
United States Rubber Co	87	198	329	521	1022	2105	....	3135	680
Okonite Co	102	157	252	461	821	1576	2896	3493	725
Average	81	169	285	487	956	1956	3089	3502	702

[a] Average for died specimen only.

(*f*) The results of all laboratories checked against the average tensile strength show a maximum variation of approximately 6 per cent if the result based on one figure is disregarded.

2. *Variation in Ultimate Elongation.*—Comparing the elongation of died *versus* undied samples, exceedingly close checks are obtained. This is not surprising, inasmuch as there are only two major factors influencing this determination, temperature and the personal equation. The average variation is only 1.6 per cent and the highest variation is 4.5 per cent.

3. *Variation in Modulus.*—At low stresses and again as ultimate elongation is approached, considerable variation is found. Taking 400 per cent and 600 per cent elongation for a basis of comparison, the percentage variation is quite small. The average variation is approximately 6 per cent for both elongations. Inasmuch as modulus and ultimate elongation are so closely connected, the conclusions noted above under tensile strength variations apply here.

4. *General.*—In general, it is reasonable to expect a variation of 6 per cent in physical testing of samples in one laboratory or in comparing the results of one laboratory against another.

The results of this test as compared against the data reported for stock No. 1 in the original investigation show the following:

(*a*) That the average tensile strength checks very closely when the average is properly taken;

(*b*) That the average stress at 400 per cent elongation also checks very closely; and

(*c*) That the variation in tensile strength as reported by individual laboratories considering only fair averages is much closer in this test than in results reported for stock No. 1.

Results on stock No. 1 show a variation in tensile strength of from 2920 to 4144 lb. per sq. in. Results on this test vary from 3232 to 3792 lb. per sq. in.

Respectfully submitted on behalf of the subcommittee,

R. A. SCHATZEL,
Chairman.

REPORT OF COMMITTEE D-13
ON
TEXTILE MATERIALS

Committee D-13 on Textile Materials has held its two customary interim meetings since the 1932 annual meeting of the Society. The fall meeting was held at the Mayflower Hotel, Akron, Ohio, on October 27 and 28, 1932, and the spring meeting at the Hotel New Yorker, New York City, on April 6 and 7, 1933. The number of members and guests in attendance at the fall and spring meetings was 50 and 60, respectively. A third meeting of the committee will be held at Chicago, Ill., in conjunction with the annual meeting of the Society in June.

The committee records with deep sorrow the death of Dr. W. F. Edwards at his home in Englewood, N. J., on January 12, 1933. Doctor Edwards was intimately identified with the work of the Society and of this committee for many years and served as the chairman of Committee D-13 for four years. His passing has caused a feeling of deep personal loss throughout our membership.

The Advisory Committee, at the spring meeting, decided to discontinue Subcommittee A-6 on Rope Fibers and Subcommittee B-3 on Knit Goods on account of their inactivity. A new Section VIII on Sewing Threads consisting of eleven members has been organized under Subcommittee A-1 on Cotton. Mr. K. B. Cook is the temporary chairman and it is the expectation that this section will be actively functioning in the fall.

Three interesting papers arranged through the Subcommittee on Papers (Dean Harvey, chairman), have been presented before the committee on the following subjects:

> "Cotton Fiber Quality; What Do We Know About It," by R. W. Webb;
>
> "Modern Testing Methods," by O. A. Belger;
>
> "A Comparison of the Skein and Serigraph Methods of Testing Cotton Yarns," by G. B. Haven.

The following members of the committee are serving as its representatives on committees of other organizations: Mr. A. M. Tenney on the Subcommittee on Rayon of the American Association of Textile Chemists and Colorists; Mr. Ephraim Freedman on the

Textile Shrinkage Committee of the Textile Section of the New York Board of Trade; Messrs. A. M. Tenney, W. H. Whitcomb, and R. T. Fisher, the latter in place of the late Dr. W. F. Edwards, on the Sectional Committee on Specifications for Sheeting functioning under the procedure of the American Standards Association.

The committee having in charge the preparation of the new edition of the D-13 Pamphlet on Textile Materials to be issued soon after the annual meeting consists of Messrs. W. H. Whitcomb, W. E. Emley, K. B. Cook, D. C. Scott, and D. G. Woolf. The pamphlet will contain all the standard and tentative specifications, methods of testing, and definitions of terms relating to textile materials which the committee has developed, and will be more conveniently indexed and arranged than the present edition.

The curtailment in business activity does not seem to have materially affected the work of this committee for it comes to the end of its year with a record of accomplishments. The officers of the committee take this opportunity to express their full appreciation of the voluntary service rendered by the chairmen and members of the subcommittees during the past year.

The present membership of the committee is 156, of whom 63 are classified as producers, 45 as consumers and 48 as general interest members.

RECOMMENDATIONS AFFECTING STANDARDS

The recommendations of the committee regarding standards and tentative standards under its jurisdiction are summarized below together with the analysis of the letter ballot on each item. Comments, where necessary, are made under the Activities of Subcommittees.

I. Proposed Tentative Standards.—The committee recommends for publication as tentative the following two new specifications and one new method of test, as appended hereto:

Tentative Specifications for Holland Cloth;[1]
Tentative Specifications for Asbestos Roving;[2]
Tentative Methods of Test for Small Amounts of Copper and Manganese in Textiles.[3]

II. Proposed Revision of Standards.—The committee is recommending revisions in nine of the present standards covering textiles. These revisions are divided into two groups as follows:

Group A.—Revisions in the following standards which the committee recommends be made immediately and accordingly asks for the necessary nine-tenths vote at the annual meeting in order that the revisions may be submitted to letter ballot of the Society for immediate adoption as standard:

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[1] See p. 924.—ED.
[2] See p. 921.—ED.
[3] See p. 927.—ED.

Standard Specifications for Tolerances and Test Methods for Tire Fabrics Other than Cord Fabrics (D 122 – 30), revised as given in Appendix I, item No. 1;

Standard Specifications for Tolerances and Test Methods for Tire Cord, Woven and on Cones (D 179 – 30), revised as given in Appendix I, item No. 2;

Standard Specifications for Tolerances for Hose Ducks and Belt Duck; (D 181 – 25), revised as given in Appendix I, item No. 3;

Standard Specifications for Tolerances and Test Methods for Cotton Yarns, Single and Plied (D 180 – 27), revised as given in Appendix I, item No. 4;

Standard Specifications for Tolerances and Test Methods for Electrical Cotton Yarns (D 203 – 25), revised as given in Appendix I, item No. 5; and

Standard Specifications for Tolerances and Test Methods for Cotton Sewing Threads (D 204 – 27), revised as given in Appendix I, item No 6.

Group B.—Revisions in the following standards recommended for publication as tentative for one year before referring them to letter ballot of the Society for adoption:

Standard General Methods of Testing Woven Textile Fabrics (D 39 – 27), revised as given in Appendix I, item No. 7;

Standard Specifications for Tolerances and Test Methods for Certain Light and Medium Cotton Fabrics (D 274 – 29), revised as given in Appendix I, item No. 8; and

Standard Specifications for Tolerances for Hose Ducks and Belt Ducks (D 181 – 25), revised as given in Appendix I, item No. 9.

III. Proposed Revision of Tentative Standards.—The committee is presenting extensive modifications of the following tentative methods and definitions and recommends that, as revised, they be continued as tentative:

Tentative Methods for Identification of Textile Fibers and Their Quantitative Determination in Mixed Goods (D 276 – 31 T),[1] completely revised, as appended hereto;[2] and

Tentative Definitions of Terms Relating to Textile Materials (D 123 – 30 T),[3] completely revised, as appended hereto.[4]

IV. Advancement of Tentative Standards to Standard.—The committee recommends that the following five tentative specifications be advanced to standard:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 1009 (1931); also 1932 Book of A.S.T.M. Tentative Standards, p. 1047.

[2] See p. 931.—ED.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 1254 (1930); also 1932 Book of A.S.T.M. Tentative Standards, p. 1070.

[4] See p. 944.—ED.

Tentative Specifications for Tolerances and Test Methods for Knit Goods (D 231 – 28 T),[1] revised as given in Appendix I, item No. 10;

Tentative Specifications and Tests for Cuban (Jute) Raw Sugar Bags (D 275 – 27 T);[2]

Tentative Specifications and Test Methods for Asbestos Tape for Electrical Purposes (D 315 – 31 T);[3]

Tentative Specifications for Chafer Tire Fabrics (D 316 – 31 T);[3] and

Tentative Specifications for Enameling Duck for the Tire Industry (D 336 – 31 T).[3]

V. Advancement of Tentative Revision of Standards to Standard.—The committee recommends that the tentative revisions[4] of the following three standards,[5] which have been standing for a year or more, be advanced to standard:

Revision of Standard Specifications for Textile Testing Machines (D 76 – 27);

Revision of Standard Specifications for Tolerances and Test Methods for Cotton Sewing Threads (D 204 – 27); and

Revision of Standard Specifications for Tolerances and Test Methods for Asbestos Yarns (D 299 – 29).

VI. Withdrawal of Standard.—The committee recommends that the Standard Definitions of Terms Relating to Textile Materials (D 123 – 30)[6] be withdrawn These definitions are being replaced by the extensive list of definitions being recommended for publication as tentative.[7]

The recommendations appearing in this report have been submitted to letter ballot of the committee, which consists of 156 members, with the results shown in the accompanying Table I.

ACTIVITIES OF SUBCOMMITTEES

Subcommittee A-1 on Cotton (K. B. Cook, chairman):

Section I on Cotton (H. H. Willis, chairman).—This section reports a limited amount of work done in relation to the spinning qualities of cotton.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 1099 (1928); also 1932 Book of A.S.T.M. Tentative Standards, p. 1012.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 27, Part I, p. 1041 (1927); also 1932 Book of A.S.T.M. Tentative Standards, p. 1024.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, pp. 996, 1000, 993 (1931); also 1932 Book of A.S.T.M. Tentative Standards, pp. 1027, 1031, 1016.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, pp. 1006, 1004, 1005 (1932); also 1932 Book of A.S.T.M. Tentative Standards, pp. 1150, 1148, 1149.

[5] 1930 Book of A.S.T.M. Standards, Part II, pp. 1060, 1072, 1099.

[6] 1930 Book of A.S.T.M. Standards, Part II, p. 1107.

[7] See p. 944.—ED.

Section II on Cotton Yarns (R. H. Adams, chairman).—This section is presenting revisions in the Standard Specifications for Tolerances and Test Methods for Cotton Yarns, Single and Plied (D 180 – 27) (item No. 4, Appendix I) and in the Standard Specifications for Tolerances and Test Methods for Electrical Cotton Yarns (D 203 – 25) (item No. 5, Appendix I). These changes insert in both specifications a method for the determination of the twist in single yarns, and stipulate the number of tests and the tolerance for single yarn twist. The recommended method removes in large part the element of the personal equation which so commonly enters into the measurement of this highly varying property of yarns. The method is one which has been found by experimentation to be rapid and to give reproducible and reasonably reliable results. In order that these two specifications may appear in their revised form in the 1933 issue of the Book of Standards, the revisions are recommended for immediate adoption as standard.

TABLE I.—ANALYSIS OF LETTER BALLOT VOTE.

Items	Affirmative	Negative	Not Voting
I. PROPOSED TENTATIVE STANDARDS			
Tentative Specifications for Holland Cloth	28	1	37
Tentative Specifications for Asbestos Roving	20	0	46
Tentative Methods of Test for Small Amounts of Copper and Manganese in Textiles	20	1	45
II. PROPOSED REVISION OF STANDARDS			
Specifications for Tolerances and Test Methods for Tire Fabrics Other than Cord Fabrics (D 122 – 30), immediate adoption	38	0	28
Specifications for Tolerances and Test Methods for Tire Cord, Woven and on Cones (D 179 – 30), immediate adoption	36	2	28
Specifications for Tolerances for Hose Ducks and Belt Ducks (D 181 – 25), immediate adoption	34	0	22
Specifications for Tolerances and Test Methods for Cotton Yarns, Single and Plied (D 180 – 27), immediate adoption	42	0	24
Specifications for Tolerances and Test Methods for Electrical Cotton Yarns (D 203 – 25), immediate adoption	30	0	36
Specifications for Tolerances and Test Methods for Cotton Sewing Threads (D 204 – 27), immediate adoption	34	0	32
General Methods of Testing Woven Textile Fabrics (D 39 – 27)	47	0	19
Specifications for Tolerances and Test Methods for Certain Light and Medium Cotton Fabrics (D 274 – 29)	37	0	29
Specifications for Tolerances for Hose Ducks and Belt Ducks (D 181 – 25)	30	0	36
III. PROPOSED REVISION OF TENTATIVE STANDARDS			
Methods for Identification of Textile Fibers and Their Quantitative Determination in Mixed Goods (D 276 – 31 T)	38	0	28
Definitions of Terms Relating to Textile Materials (D 123 – 30 T)	49	1	16
IV. ADVANCEMENT OF TENTATIVE STANDARDS TO STANDARD			
Specifications for Tolerances and Test Methods for Knit Goods (D 231 – 28 T), as revised	24	1	41
Specifications and Tests for Cuban (Jute) Raw Sugar Bags (D 275 – 27 T)	19	2	37
Specifications and Test Methods for Asbestos Tape for Electrical Purposes (D 315 – 31 T)	21	0	45
Specifications for Chafer Tire Fabrics (D 316 – 31 T)	29	2	35
Specifications for Enameling Duck for the Tire Industry (D 336 – 31 T)	30	2	34
V. ADVANCEMENT OF TENTATIVE REVISION OF STANDARDS TO STANDARD			
Specifications for Textile Testing Machines (D 76 – 27)	46	2	18
Specifications for Tolerances and Test Methods for Cotton Sewing Threads (D 204 – 27)	31	1	34
Specifications for Tolerances and Test Methods for Asbestos Yarns (D 299 – 29)	25	0	41
VI. WITHDRAWAL OF STANDARD			
Standard Definitions of Terms Relating to Textile Materials (D 123 – 30)	44	0	22

Section III on Light and Medium Cotton Woven Fabrics (R. T. Fisher, chairman).—This section is presenting for publication as tentative, revisions of the Standard Specifications for Tolerances and Test Methods for Certain Light and Medium Cotton Fabrics (D 274 - 29) (item No. 8, Appendix I). Changes are made in the present tentative method for determination of tear resistance to correspond to those more fully set forth hereafter under Subcommittee B-1, Section I. There is also incorporated in the specifications a shrinkage test procedure based upon that developed by the American Association of Textile Chemists and Colorists. The need for such a test for washable cotton fabrics is the reason for its inclusion.

Section IV on Tire Fabrics (B. H. Foster, chairman).—The work of this very active section has resulted in numerous recommendations. The section is presenting proposed Tentative Specifications for Holland Cloth, appended hereto,[1] which cover the No. 1 and No. 2 constructions of this fabric for use in the tire industry. A test for plucking or flaking will be inserted later as soon as a satisfactory one has been developed. The specifications were prepared as a result of a demand for them by both producers and consumers of this material.

In the Standard Specifications for Tolerances and Test Methods for Tire Fabrics Other than Cord Fabrics (D 122 - 30) (item No. 1, Appendix I), the section is presenting for immediate adoption revisions which incorporate a method for the determination of the twist in single yarns and tolerance for single yarn twist identical with that referred to under Subcommittee A-1, Section II. In the Standard Specifications for Tolerances and Test Methods for Tire Cord, Woven and on Cones (D 179 - 30) (item No. 2, Appendix I), the section is incorporating the same method of single twist determination and tolerance. Additional changes include a tolerance for the average weight of cord on cones, a method and tolerance for determining the yards per pound from cones, sections dealing with adjustment for moisture regain against shipments, and a method of calibrating and checking cord testing machines. In order that these two specifications may appear in their revised form in the 1933 issue of the Book of Standards, the revisions are recommended for immediate adoption as standard.

The section has received no important criticisms of the Tentative Specifications for Chafer Tire Fabrics (D 316 - 31 T) and the Tentative Specifications for Enameling Duck for the Tire Industry (D 336 - 31 T) while in the tentative status. It believes them to be entirely satisfactory and is accordingly recommending their advancement to standard.

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[1] See p. 924.—ED.

Section V on Hose, Belt, and Numbered Duck (B. L. Whittier, chairman).—This section is presenting two types of revisions in the Standard Specifications for Tolerances for Hose Ducks and Belt Ducks (D 181 - 25) (items Nos. 3 and 9, Appendix I). First, item No. 3, by suitably changing the captions of certain sections to make them more inclusive, tolerances for certain specific classes of ducks are deleted without impairing the present character, usefulness, and breadth of the specifications. The section is requesting immediate adoption of these revisions as standard. Second, the section is making the specifications more complete by including methods of test for width, weight, count, thickness, crimp, and tensile strength. These revisions are represented by the new sections referred to in item No. 9, Appendix I, and are being recommended for publication as tentative.

Section VI on Narrow Fabrics (F. S. Mapes, chairman).—This section reports that interest in specifications for shoe tapes is lacking, but that it is still working upon the development of interest in specifications for automotive webbing. This section is reporting the withdrawal of Standard Specifications for Tolerances and Test Methods for Electrical Silk and Cotton Tapes (D 259 - 27) which have been replaced by the existing Tentative Specifications D 259 - 31 T.

Section VIII on Sewing Threads (K. B. Cook, acting chairman).—This section has now been organized with a membership of eleven. It is presenting revisions in the Standard Specifications for Tolerances and Test Methods for Cotton Sewing Threads (D 204 - 27) (item No. 6, Appendix I), which add the same method of determining the twist in single yarns that is referred to under Subcommittee A-1, Section II. In order that these specifications may appear in their revised form in the 1933 issue of the Book of Standards, the revisions are recommended for immediate adoption as standard. The section is also recommending that the tentative revision in these specifications which has been standing for more than a year, be advanced to standard.

Subcommittee A-2 on Rayon (A. M. Tenney, chairman):

Section I on Rayon (A. M. Tenney, chairman).—This section is working upon a complete revision of the Tentative Specifications for Tolerances and Test Methods for Rayon (D 258 - 32 T) and hopes to present them during the coming year.

Section II on Rayon Fabrics (Alexis Sommaripa, chairman).—This section reports a well attended and interesting session on methods of testing rayon linings.

Subcommittee A-3 on Wool (G. E. Hopkins, chairman):

This newly organized subcommittee now has a membership of seventeen, and it is busily at work upon several important projects. Methods for determining the hard scoured content of wool will soon be ready for presentation. Until such time the subcommittee recommends that the Tentative Methods of Testing Grease Wool and Allied Fibers for Scoured Content (D 232 – 25 T) be continued as tentative. Work on specifications for felt and for woolen and worsted yarns is showing progress but those for woolen and worsted fabrics are temporarily being held in abeyance until a more extensive representation of cloth manufacturers can be secured. An extensive glossary of wool terms will soon be ready to forward to Subcommittee B-2 on Nomenclature and Definitions.

Subcommittee A-4 on Asbestos:

Section I on Asbestos Textiles (J. M. Weaver, chairman).—The progressive work of this section has resulted in the completion of proposed Specifications for Asbestos Roving which are being presented for publication as tentative, as appended hereto.[1] The section has received no important criticisms of the Tentative Specifications and Test Methods for Asbestos Tape for Electrical Purposes (D 315 – 31 T) while in the tentative status. It believes them to be entirely satisfactory and is accordingly recommending their advancement to standard. For the same reason it is recommending that the tentative revision which has been standing for more than a year in the Standard Specifications for Tolerances and Test Methods for Asbestos Yarns (D 299 – 29) be advanced to standard.

Subcommittee A-5 on Jute, Ramie, and Linen:

Section 1 on Sugar Bags (A. E. Davieau, chairman).—This section is recommending that the Tentative Specifications and Tests for Cuban (Jute) Raw Sugar Bags (D 275 – 27 T) be adopted as standard. The recognition of these specifications by the Indian Jute Mills Association of Calcutta, India, which it was hoped might be secured, seems to be no nearer on account of the continuance of troubled conditions in that country. Furthermore, these specifications have been tentative since 1927, which is ample time for criticism, and the section accordingly believes they should be adopted as standard.

Subcommittee B-1 on Methods and Machines (W. D. Appel, chairman):

Section I on Methods (W. D. Appel, chairman).—This section is presenting for publication as tentative, revisions in the Standard

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[1] See p. 921.—ED.

General Methods of Testing Woven Textile Fabrics (D 39 - 27) (item No. 7, Appendix I), which greatly improve the standard. These changes introduce a new test procedure for the determination of elongation; they interchange the present preferred and alternate methods for determining tear resistance and make the speed of the pulling jaw alike for both tests; finally, they revise the definition of crimp therein to agree with the standard definition.

This section has completely rewritten the Tentative Methods for Identification of Textile Fibers and Their Quantitative Determination in Mixed Goods (D 276 - 31 T) and is presenting the greatly changed and improved procedures as a revision of the present tentative methods under the new title of Tentative Methods for the Identification of Fibers in Textiles and for the Quantitative Analysis of Textiles, as appended hereto.[1] The methods for identification contain an abridged key for use with mixtures of the commonest fibers, such as, cotton, linen, jute, rayon, silk, and wool. A more comprehensive analytical key is also included for general mixtures of all important fibers of mineral, animal, and vegetable origin. The method of analysis provides for the quantitative determination of the water, total non-fibrous materials, cellulose acetate rayon, silk, regenerated cellulose rayon, wool, and cotton present in textiles composed of two or more of these materials. The section is preparing a new set of photomicrographs of fibers to be included as an appendix to the revised methods.

Section II on Machines (H. J. Ball, chairman).—This section is recommending that the revision which has been standing as tentative for more than a year in the Standard Specifications for Textile Testing Machines (D 76 - 27) be advanced to standard.

Subcommittee B-2 on Nomenclature and Definitions (A. L. Brassell, chairman):

This subcommittee is presenting for publication as tentative a new and expanded list containing 139 textile definitions and terms. This contains some definitions which are found in the present Standard Definitions of Terms Relating to Textile Materials (D 123 - 30) and in the Tentative Definitions of Terms Relating to Textile Materials (D 123 - 30 T), as well as many new terms. The changes are so extensive that the subcommittee is recommending the withdrawal of the Standard Definitions D 123 - 30 and is presenting the new list, appended hereto,[2] as a revision of the Tentative Definitions D 123 - 30 T.

This subcommittee has many more terms under consideration for which it hopes to present acceptable definitions in the near future.

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[1] See p. 931.—ED.

[2] See p. 944.—ED.

It is also collaborating with Subcommittee A-3 on Wool on a list of definitions and terms relating particularly to wool.

Subcommittee B-3 on Knit Goods (A. E. Davieau, temporary chairman):

This subcommittee is presenting revisions in the Tentative Specifications for Tolerances and Test Methods for Knit Goods (D 231 – 28 T) (item No. 10, Appendix I). The changes are made so as to include the motor-driven diaphragm bursting tester as an approved type of testing machine. This decision was reached after a consideration of data obtained from comparative tests of the two types of testers which are in commercial use. In the absence of criticism while in the tentative status, the subcommittee believes the specifications to be entirely satisfactory, and is accordingly recommending that they be advanced to standard as revised.

Subcommittee B-4 on Bleaching, Dyeing and Finishing (W. M. Scott, chairman):

One result of the activities of this subcommittee is the proposed Methods of Test for Small Amounts of Copper and Manganese in Textiles, appended hereto,[1] which the committee is recommending for publication as tentative. These methods are needed because the presence of even small amounts of copper and manganese will render textiles unfit for impregnation or for use with certain materials.

The subcommittee is investigating a micro-analytical method for copper in which the percentage present is determined colorimetrically by the use of sodium-diethyl-dithio-carbamate as an indicator. It hopes to present in the near future methods for the determination of sizing materials in textiles which will be in general accord with those developed by other scientific agencies. The subcommittee soon expects to recommend suitable tests for fastness to washing. It has given its approval to the shrinkage test now being presented by Subcommittee A-1, Section III.

This report has been submitted to letter ballot of the committee, which consists of 156 members; 66 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

H. J. BALL,
Chairman.

W. H. WHITCOMB,
Secretary.

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[1] See p. 927.—ED.

EDITORIAL NOTE

The proposed Tentative Specifications for Holland Cloth, for Asbestos Roving and Methods of Test for Small Amounts of Copper and Manganese in Textiles were accepted for publication as tentative and appear on pages 924, 921 and 927, respectively.

Revisions proposed for immediate adoption in the Standard Specifications for Tolerances and Test Methods for Tire Fabrics Other than Cord Fabrics, for Tolerances and Test Methods for Tire Cord, Woven and on Cones, for Tolerances for Hose Ducks and Belt Ducks, for Tolerances and Test Methods for Cotton Yarns, Single and Plied, for Tolerances and Test Methods for Electrical Cotton Yarns and for Tolerances and Test Methods for Cotton Sewing Threads were approved at the annual meeting by a unanimous vote and were subsequently adopted by letter ballot of the Society on September 1, 1933. The specifications in their revised form appear in the 1933 Book of A.S.T.M. Standards, Part II, pages 1220, 1205, 1186, 1176, 1171, and 1200, respectively.

The proposed revisions of the Standard General Methods of Testing Woven Textile Fabrics, the Specifications for Tolerances and Test Methods for Certain Light and Medium Cotton Fabrics and the Specifications for Tolerances for Hose Ducks and Belt Ducks were accepted for publication as tentative and appear on pages 1047, 1045 and 1044, respectively.

The proposed revisions of the Tentative Methods for Identification of Textile Fibers and Their Quantitative Determination in Mixed Goods and of the Tentative Definitions of Terms Relating to Textile Materials were accepted. The methods and definitions in their revised form appear on pages 931 and 944.

The Tentative Specifications for Tolerances and Test Methods for Knit Goods, as revised, Specifications and Tests for Cuban (Jute) Raw Sugar Bags, Specifications and Test Methods for Asbestos Tape for Electrical Purposes, Specifications for Chafer Tire Fabrics and for Enameling Duck for the Tire Industry were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1933. The standards appear in the 1933 Book of A.S.T.M. Standards, Part II, pages 1191, 1188, 1163, 1215, and 1183, respectively.

The tentative revisions of the Standard Specifications for Textile Testing Machines, Specifications for Tolerances and Test Methods for Cotton Sewing Threads and for Asbestos Yarns were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1933. The specifications in their revised form appear in the 1933 Book of A.S.T.M. Standards, Part II, pages 1198, 1200, and 1161, respectively.

The withdrawal of the Standard Definitions of Terms Relating to Textile Materials was approved.

APPENDIX I

PROPOSED REVISIONS IN STANDARDS FOR TEXTILE MATERIALS

In this Appendix are given the proposed revisions of standards and tentative standards referred to in the body of this report and which, for ease of reference, are numbered 1 to 10, inclusive. Reference is also given to the publication in which each standard appears in its present form.

Proposed Revisions of Standards

Group A. Revisions Recommended for Immediate Adoption

No. 1. Standard Specifications for Tolerances and Test Methods for Tire Fabrics Other Than Cord Fabrics (D 122 – 30):[1]

Section 7.—Change to read as follows by the addition of the italicized words and the omission of the word in brackets:

7. The average [ply] twist, *either single or plied, as* determined by test shall not be more than 5 per cent over or under the specified twist.

Section 16.—Add the following as a new Paragraph (*a*) under this section on Twist and renumber the present Section 16 as Paragraph (*b*):

16. (*a*) The single yarn twist shall be determined on any standard single yarn twist tester employing the principle of first taking the twist out of a given length of yarn and then retwisting in the opposite direction until the same amount of twist is put back, dividing the results by twice the distance between grips to get the twists per inch. The minimum distance between jaws shall be 5 in., but a 10-in. distance is preferable. In making this test it is essential that check tests be made before proceeding with regular tests in order to determine the proper tension to be placed on the yarn so as not to cause slippage of the fibers and other variations. At least 30 individual twist tests shall be made and the average of these shall be the average single yarn twist.

No. 2. Standard Specifications for Tolerances and Test Methods for Tire Cord, Woven and on Cones (D 179 – 30):[2]

Section 3.—Add the following as a new Paragraph (*c*) of this section:

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 1081.

[2] 1930 Book of A.S.T.M. Standards, Part II, p. 1085.

(*c*) The average weight of cord on cones, generally expressed in yards per pound, as determined by test shall not be more than 2 per cent over or under the specified yards per pound.

Section 8.—Add the following as a new Paragraph (*a*), relettering the present paragraphs accordingly:

(*a*) The average twist of the single yarn as determined by test shall not be more than 5 per cent over or under the specified twist.

New Methods of Testing.—A new single yarn twist test, tests for yarn per pound from cones, methods dealing with adjustment for moisture regain against shipments, and a method of calibrating and checking cord testing machines are recommended for inclusion at the end of this standard. These methods appear in Appendix II.[1]

No. 3. Standard Specifications for Tolerances for Hose Ducks and Belt Ducks (D 181 - 25):[2]

Section 3.—Change the italicized caption "Rubber and Balata Belt Ducks," by the omission of the words "Rubber and Balata" so that the caption reads "Belt Ducks."

Section 4.—Omit entirely this section on Stitched Canvas Belting Ducks, renumbering the subsequent sections accordingly.

Section 6.—Change the heading preceding Section 6, reading "Threads per Inch," to read "Count." Change the italicized caption "Hose Ducks" to read "Hose and Belt Ducks."

Sections 7 and 8.—Omit entirely these sections on Rubber Belt Ducks and Stitched Canvas Belting Ducks, renumbering the subsequent sections accordingly.

Section 9.—Change the heading preceding Section 9, reading "Gage," to read "Thickness (Gage)."

Section 10.—Make the same change in the caption of this section as is recommended in Section 3 above.

No. 4. Standard Specifications for Tolerances and Test Methods for Cotton Yarns, Single and Plied (D 180 - 27):[3]

Section 5.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

5. The average twist of each case, bale, chain ball or beam warp of [plied yarns] *yarn, either single or plied,* as [found] *determined* by test shall not [vary] *be* more than 5 per cent [above] *over* or [below] *under* [that] *the* specified *twist.*

EXAMPLE.—Twist specified is 20 twists per inch; tolerance 19 to 21.

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[1] The new testing procedures have been incorporated in the revised Standard Specifications for Tolerances and Test Methods for Tire Cord, Woven and on Cones, see 1933 Book of A.S.T.M. Standards, Part II, p. 1205.

[2] 1930 Book of A.S.T.M. Standards, Part II, p. 1090.

[3] 1930 Book of A.S.T.M. Standards, Part II, p. 1062.

Section 17.—Change from its present form: namely,

17. No precision method for determining the twist of single yarns has been developed.

to read as follows:

17. The single yarn twist shall be determined on any standard single yarn twist tester employing the principle of first taking the twist out of a given length of yarn and then retwisting in the opposite direction until the same amount of twist is put back, dividing the results by twice the distance between grips to get the twists per inch. The minimum distance between jaws shall be 5 in., but a 10-in. distance is preferable. In making this test it is essential that check tests be made before proceeding with regular tests in order to determine the proper tension to be placed on the yarn so as not to cause slippage of the fibers and other variations.

Section 19.—Change to read as follows by the addition of the italicized words and figures:

19. (*a*) *Single Yarns.—Three twist tests on each of ten packages of single yarn from each case or bale shall be made, and the average of these 30 tests shall be the average of the case. In the case of bales, chain ball or beam warp, at least 30 tests shall be made per unit.*

(*b*) *Plied Yarns.*—Three twist tests on each of four packages of *plied* yarn from each case shall be made, and the average of these 12 tests shall be the average of the case. *In the case of bales, chain ball or beam warp, at least 12 tests shall be made per unit.*

No. 5. Standard Specifications for Tolerances and Test Methods for Electrical Cotton Yarns (D 203 - 25):[1]

Section 5.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

5. The average twist of each case or bale of [plied] yarn, *either single or plied*, as determined by test shall not [vary] *be* more than 5 per cent [above] *over* or [below that] *under the* specified *twist*.

EXAMPLE.—Twist specified is 20 twists per inch; tolerance 19 to 21.

Section 22.—Add as a new Paragraph (*a*) the test for single yarn twist as recommended in Section 17 of Specifications D 180 - 27 above, lettering the present Section 22 as Paragraph (*b*).

Section 23.—Change to read as follows by the addition of the italicized words and figures:

23. (*a*) *Single Yarns.—Three twist tests on each of ten packages of single yarn from each case or bale shall be made, and the average of these 30 tests shall be the average twist of the case or bale.*

(*b*) *Plied Yarns.*—Three twist tests on each of four packages of *plied* yarn from each case *or bale* shall be made, and the average of these 12 tests shall be the average *twist* of the case *or bale.*

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 1068.

No. 6. Standard Specifications for Tolerances and Test Methods for Cotton Sewing Threads (D 204 – 27):[1]

Section 10.—Substitute for the present section, which reads as follows, the test for single yarn twist as recommended in Section 17 of Specifications D 180 – 27 above:

> 10. No precision method for determining the twist of single yarns has been developed.

Group B. Revisions Recommended for Publication as Tentative

No. 7. Standard General Methods of Testing Woven Textile Fabrics (D 39 – 27):[2]

Section 13.—Replace the last sentence of this section, which reads as follows:

> The crimp shall be the ratio between the final length of the thread and its original length in the cloth.

by the following sentence:

> The crimp shall be the difference in distance between two points of the yarn as it lies in the fabric, and the same two points when the yarn has been removed from the fabric and straightened, expressed as a percentage of the distance between the two points as the yarn lies in the fabric.

Tear Resistance Test.—Make the following change in the proposed test for tear resistance[3] which has been published as a tentative revision of these methods:

> In the present alternate method of test for tear resistance, increase the speed of the pulling jaw from "3 in. per minute" to "12 in. per minute."
>
> Make the present alternate method of test for tear resistance the preferred method, and the present preferred method the alternate method.

Elongation Test.—Add the following elongation test procedure as a new Section 15 of these methods:

ELONGATION

> 15. Unless otherwise specified, the elongation of cloth at any stated load shall be obtained when the breaking strength is determined and for the same specimens by means of a suitable autographic recording device on the testing machine. The elongation shall be the average of the results obtained for five specimens. It shall be expressed as the percentage increase in length. Since the initial length and therefore the measured elongation depend upon the load applied in placing the specimen in the jaws of the machine, an initial load just under that required to register on the dial of the machine should be used. In practice, it is advantageous to place the specimen in the machine at a somewhat lower load and to calculate the initial length of the specimen from

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 1072.

[2] *Ibid.*, p. 1102.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 1007 (1932); also 1932 Book of A.S.T.M. Tentative Standards, p. 1151.

the distance between the jaws of the machine when the test is started and the distance the jaws separate before a just perceptible load is assumed by the specimen, as shown by the graphic record.

No. 8. Standard Specifications for Tolerances and Test Methods for Certain Light and Medium Cotton Fabrics (D 274 – 29):[1]

Tear Resistance Test.—In the tear resistance test,[2] published as a tentative revision of these specifications, make the same changes as recommended in the Standard Methods D 39 – 27 above.

Shrinkage Test.—Add the following shrinkage test procedure as Sections 9 to 13, inclusive.

SHRINKAGE TEST

9. *Test Sample.*—The sample for the shrinkage test shall be at least 20 in. square, and shall be cut from the fabric in such a way as to be fairly representative of the material, or it may be a piece 20 in. in length and the full width of the goods. There shall be marked off accurately on the sample, in both the warp and filling directions, three 18-in. lengths by means of fine indelible ink lines or by fine threads sewed into the fabric. Care shall be taken to see that the marks run parallel with the threads.

10. *Apparatus.*—The washing shall preferably be carried out in a reversing wash wheel of the cylindrical type. The wheel shall be equipped with a steam pipe so that the water can be heated directly in the wheel by means of live steam. A standard load shall consist of approximately 3 lb. of dry samples and an amount of water equal to 50 times the weight of the samples. The proportion of water may be increased if necessary to insure that the samples are thoroughly covered.

11. *Soap Solution.*—An amount of laundry soap of good grade shall be used sufficient to make a good running suds. The soap shall be dissolved before adding it to the wash wheel. A good stock solution can be made by thoroughly dissolving 1 lb. of chip soap in 1 gal. of hot water.

12. *Procedure.*—The shrinkage test shall be carried out in accordance with Paragraphs (*a*) to (*c*). During the shrinkage test procedure, which requires exactly 60 minutes, the wash wheel shall be kept running continuously.

(*a*) *Washing.*—Place the samples to be tested in the wheel and start it. Turn on the water and the steam. If steam is not available, heat the water separately and add it to the wheel. Fill the wheel to the proper water level and then add the soap. Turn off the steam when the water boils (212 F., 100 C.). Allow the wheel to run for 40 minutes from the time it started, and then draw off the water. Fill the wheel again to the proper level with water and raise its temperature to 140 F. (60 C.). Run the wheel for 5 minutes, and then draw off the water. Fill the wheel again to the proper level with water and raise its temperature to 140 F. (60 C.). Run the wheel for 10 minutes. Draw off the water and run the wheel for 5 minutes, tumbling the wet samples in the wheel while the water drains.

(*b*) *Drying.*—Remove the samples from the wheel, *squeezing* the excess water from them by hand. Do not wring the samples by hand or by means of a wringer, as either method may distort the material and give unsatisfactory results. Spread the samples horizontally to dry on a screen or ventilated surface. Do not hang the samples vertically to dry. If available, dry the samples in a heated drying chamber, otherwise in a current of air at room temperature from an electric fan. When the samples are dry, lay them out smoothly without stretching on a table, and dampen. Allow them to condition for 5 minutes.

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 1075.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, pp. 859, 1279 (1930); also 1932 Book of A.S.T.M. Tentative Standards, p. 1150.

(*c*) *Pressing.*—Two methods of pressing shall be recognized, by means of a hand iron or by means of a flat bed press, as follows:

Hand Pressing.—Lay out the conditioned samples on a padded ironing table, carefully smooth out all noticeable wrinkles, and press by raising and lowering the iron. Do not slide the iron back and forth on the samples as this may distort the cloth. Allow the samples to cool, and then measure them carefully to determine any changes in the marked lengths.

Machine Pressing.—Lay out the conditioned samples on the bed of the press, carefully smooth out all noticeable wrinkles, and press by lowering the head of the machine. Remove samples from the bed of the machine in such a manner as to cause no strain on the cloth. Allow the samples to cool, and then measure them carefully to determine any changes in the marked lengths.

13. *Results.*—The results shall be reported separately for both warp and filling directions, and shall be the average obtained from the three marked lengths. The results may be expressed in inches per yard or as a percentage of the original length.

No. 9. Standard Specifications for Tolerances for Hose Ducks and Belt Ducks (D 181 – 25):[1]

Title.—Change the title of this standard by the addition of the words "and test methods" after "tolerances."

Methods of Testing.—Add the following methods of testing as Sections 9 to 15, inclusive, of this standard:

METHODS OF TESTING

9. All test procedure not covered in these specifications shall be in accordance with the Standard General Methods of Testing Woven Textile Fabrics (A.S.T.M. Designation: D 39) of the American Society for Testing Materials.

10. *Width.*—The average width shall be determined by measuring at five different places uniformly distributed along the full length of the roll. No measurement shall be considered within 3 yd. of either end of the roll.

11. *Weight.*—(*a*) The net weight of the roll from which the covering has been removed shall be determined.

(*b*) The standard weight of the full roll shall be determined from the following formula:

$$\text{Standard weight} = \frac{\text{Actual width} \times \text{Basic weight} \times \text{Length}}{\text{Basic width} \times 16}$$

(*c*) Comparison of the net weight with the standard weight of the full roll shall be used in determining the percentage light or heavy.

12. *Count.*—The average number of ends and picks per inch of the fabric shall be determined by counting a space not less than 1 in. in five different

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 1090.

places uniformly distributed along the full length of the roll. No count shall be considered within 6 in. of the selvages nor within 3 yd. of either end of the roll.

13. *Thickness* (*Gage*).—The average thickness of the fabric shall be determined by means of an automatic micrometer equipped with a foot ⅜ in. in diameter. The foot of the micrometer shall be raised ¼ in. above the fabric and allowed to drop under a dead weight pressure of 6 oz. The gage shall be taken in five different places uniformly distributed along the full length of the roll. No gage shall be considered within 6 in. of the selvages nor within 3 yd. of either end of the roll.

14. *Crimp.*—(*a*) The average crimp of warp or filling shall be determined by testing at least four adjacent samples each of warp and filling yarns under standard conditions.

(*b*) The yarns for test shall be taken from the inside edge of the test piece as near the center line of the roll as possible.

(*c*) The yarns shall then be straightened by a machine which applies a definite tension of 150 g.

15. *Tensile Strength.*—(*a*) The average tensile strength shall be determined by testing five samples each of warp and filling on any standard type of inclination balance machine of 400 and 800-lb. capacities.

(*b*) The lower capacity of the testing machine shall be used until the swing of the pendulum exceeds an angle of 45 deg. from the vertical. When the fabric breaks above this mark, the higher capacity of the testing machine shall be used. The speed of the pulling jaw shall be 12 in. per minute. The length of the test specimen between nip of jaws shall be 3 in.

(*c*) Tensile strength shall be determined by the Grab Test as defined in Section 12 of the Standard General Methods of Testing Woven Textile Fabrics (A.S.T.M. Designation: D 39) of the American Society for Testing Materials, the samples for testing having been brought to a standard condition as defined in Section 3 of the Standard Methods D 39.

PROPOSED REVISION OF TENTATIVE STANDARD

No. 10. Tentative Specifications for Tolerances and Test Methods for Knit Goods (D 231 – 28 T):[1]

Section 13.—Change Paragraph (*a*) to read as follows by the addition of the italicized words:

13. (*a*) The strength shall be determined on *either* an approved type of inclination balance breaking machine *or an approved type of diaphragm bursting tester.*

Inclination Balance Breaking Machine.—The sample shall be securely held by a ring mechanism not less than 1¾ in. in internal diameter and be drawn down against a 1-in. polished steel ball until a burst is produced. The maximum capacity of the machine shall be such that the position of the pendulum shall not be greater than 45 deg. from the vertical when the break occurs. The minimum capacity shall not be less than 20 per cent of the above maximum capacity.

Diaphragm Bursting Tester.—The strength shall be determined on an approved type of diaphragm bursting tester. The sample shall be securely held by a top and bottom ring mechanism with openings not less than 1.2 in. in diameter.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 1099 (1928); also 1932 Book of A.S.T.M. Tentative Standards, p. 1012.

REPORT OF COMMITTEE D-17

ON

NAVAL STORES

Committee D-17 on Naval Stores has held one meeting during the year in Washington, D. C., on March 29.

The committee has completed the preparation of proposed Methods of Sampling and Testing Rosin, which appear in Appendix I to this report. These proposed methods have been assembled primarily for the purpose of eliciting criticism and suggestions and are accordingly published at this time for information. The methods have been tried out extensively in the laboratory and found to give reliable, concordant results in the hands of experienced analysts.

The Subcommittee on Viscosity of Rosin (C. E. Kinney, chairman) has conducted a series of careful cooperative viscosity tests on four samples of rosin—sample No. 1 wood rosin, grade N, sample No. 2 gum rosin, grade M, sample No. 3 wood rosin, grade FF, and sample No. 4 gum rosin, grade G. All of the tests were carried out in accordance with the proposed Method of Test for Viscosity of Rosin (Ring-and-Ball Method) developed by the viscosity subcommittee, and which appears in Appendix II to this report.

Eleven analysts, representing eight laboratories, participated in this cooperative work. A summary of the data obtained is presented in the accompanying Table I.

This report has been submitted to letter ballot of the committee which consists of 17 members; 13 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

F. P. Veitch,
Chairman.

C. F. Speh,
Secretary.

Table I.—Viscosity of Rosin Determined in Cooperative Tests Using Proposed Viscosity Test (Ring-and-Ball Method).

Collaborator	Sample No. 1 Wood Rosin, Grade N		Sample No. 2 Gum Rosin, Grade M		Sample No. 3 Wood Rosin, Grade FF		Sample No. 4 Gum Rosin, Grade G	
	End Point, deg. Cent.	Average End Point, deg. Cent.	End Point, deg. Cent.	Average End Point, deg. Cent.	End Point, deg. Cent.	Average End Point, deg. Cent.	End Point, deg. Cent.	Average End Point, deg. Cent.
Mr F. P. Veitch (Mr. W. C. Smith)[a]....	76.4 76.6 76.6 76.6	76.6	78.6 79.0 78.0 78.0	78.4	73.2 73.0 72.6 73.0	72.9	78.6 79 6 79.0 79.0	79.0
Mr. F. P. Veitch (Mr. C. K. Clark)[a]	76.0 76.0 76.5 76.5	76.2	79.5 79.5 79.5 79.5	79.5	71.5 72.0 72.0 71.5	71.7	76.5 76.5 77.5 77.5	77.0
Mr. V. E. Grotlisch[a].	75.0 75.2 76.2 76.4 76.6 76.6	76.0	78.8 78.8 78.7 79.0	78.8	72.4 72.5 72.4 72.6	72.5	78.6 .... 78.6 78.6	78.6
Mr. P. H. Walker (Operator "A") ..	77.0 76.0	76.5	79.0 78.5	78.7	73.5 73.0	73.2	80.5 78.5 79.5	79.5
Mr. P. H. Walker (Operator "B") ..	77.0 76.5	76.7	79.5 78.5	79.0	73.0 73.0	73.0	79.5 78.5 79.0 79.0	79.0
Mr. H. A. Gardner .. (Mr. G. G. Sward)	76.5 75.5 75.0	75.7	78.0 77.5 77.5	77.7	73.0 72.5 72.5	72.7	78.5 77.6 78.1	78.7
Hercules Powder Co. (Mr. W. N. Traylor)[b]...........	76.2 76.2 76.3	76.2	79.0 79.0 79.3	79.1	72.5 73.0 73.0	72.8	78.6 78.7 78.9	78.7
Armstrong Cork Co. (Mr. H. R. Woerner).............	76.4 76.4 76.6	76.5	79.5 79.0 79.0	79.2	72.9 73.0 73.2	73.0	78.6 78.6 78.5	78.6
Western Electric Co. (Mr. H. S. Snell)..	75.5 76.3 76.5	76.1	78.5 78.3 78.5	78.4	73.0 72.8 72.5	72.8	78.0 77.8 78.3	78.0
Hercules Powder Co. (Mr. D. H. Sheffield)............	73.7 73.7 74.6	74.0	76.7 77.4 78.0	77.4	70.0 70.6 70.5	70.4	78.9 79.0 79.8	79.2
Newport Industries, Inc. (Mr. R. C. Palmer)..........	76.0 75.5 75.6	75.7	78.0 77.8 78.2	78.0	72.3 72.2 72.0	72.2	78.0 77.5 77.8	77.8
Highest individual result...........	77.0 C.		79.5 C.		73.5 C.		80.5 C.	
Lowest individual result.............	73.7 C.		77.4 C.		70.0 C.		76.5 C.	
Difference between highest and lowest result...........	3.3 C.		2.1 C.		3.5 C.		4.0 C.	
Highest average result.............	76.7 C.		79.5 C.		73.2 C.		79.5 C.	
Lowest average result..............	75.7 C.		77.4 C.		70.4 C.		77.0 C.	
Mean average result.	76.2 C.		78.4 C.		71.8 C.		78.2 C.	
Greatest deviation from average	0.5 C.		1.1 C.		1.4 C.		1.2 C.	

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[a] Thermometer B. S. 34881 complying with the specifications of the Bureau of Standards (see Research Paper No. 142, U. S. Bureau of Standards *Journal of Research*, Vol. 4, No. 2, p. 195 (1930)) was used. Checked against A. H. Thomas thermometer 9538 used for referee work and found in agreement.

[b] Hercules Type "AO" thermometer was used. Checked against A. H. Thomas thermometer 9538 used for referee work and found in agreement.

APPENDIX I

PROPOSED METHODS OF SAMPLING AND TESTING ROSIN[1]

In few instances is any examination made of rosin except to determine its color grade, using duplicates of the "United States Rosin Standards," universally used for this purpose. For some special uses other examination may be necessary, and the methods given here are for use as far as they are applicable. If other test methods are needed, the need should be brought to the attention of the secretary of Committee D-17.

Gum rosin, that is, rosin made from the oleoresin which has exuded from the tree, is made in batches of from six to eight 500-lb. barrels or drums. Therefore, a sample drawn from any one package cannot be expected to represent more than the six or eight barrels made in a batch of which the barrel sampled was one. However, when such a single sample is drawn anywhere but at the still where the batch is made it may have no relation to any barrel in the lot other than the barrel from which the sample is taken.

It will be seen, therefore, that the results of the analysis or colorimetric examination of either one sample taken from a single barrel, or samples taken from a number of barrels of a large lot of rosin, even though they are all of the same grade, must be considered in the light of the above mentioned facts and with the knowledge of the lack of representative character of the sample.

The above statement does not apply in anything like the same extent to wood rosin which is made by extracting the rosin from chipped wood with light petroleum oils which are distilled off before the rosin is run into barrels or drums.

Nevertheless, as a rule, gum rosins differ to only a limited extent in their physical constants, there being but little more variation in the constants between rosins of different grades than between the rosins of the same grade.

Gum Rosin.—Physical constants of gum rosin, as a rule, fall within the following limits:

Melting point (capillary tube method)....	60 to 75 C. (140 to 168 F.)
Acid value[a]............................	158 to 172
Saponification value[a]	167 to 184
Unsaponifiable matter[b]	5.6 to 10.7 per cent
Ash[c]...................................	0.015 to 0.10 per cent
Iodine number (Wijs method)[d]...........	205 to 230

[a] The lighter grades tend to have the higher values.

[b] There is no apparent relation between grade and percentage of unsaponifiable matter.

[c] For samples free from excessive dirt. Commercially clean rosin has an average ash of 0.020 per cent. The ash consists chiefly of silica and iron oxide.

[d] B and D rosins usually have low iodine numbers. Other grades average about 222. The pale grades tend to have higher iodine numbers than the lower grades.

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[1] Criticisms of these proposed methods are solicited and should be directed to Mr. C. F. Speh, Secretary of Committee D-17 on Naval Stores, Pine Inst. of America, Barnett National Bank Building, Jacksonville, Fla.

Wood Rosin.—Physical constants of normal untreated wood rosin of FF grade, as a rule, fall within the following limits:

Melting point (capillary tube method)....	55 to 62 C. (131 to 144 F.)
Acid value....................................	150 to 158
Saponification value........................	162 to 171
Unsaponifiable matter.....................	8.5 to 14.0 per cent
Iodine number (Wijs method)...........	214 to 218
Ash..	less than 0.05 per cent

SAMPLE FOR ANALYSIS

1. Sample for analysis should consist of a single lump of about 1 lb., and this lump shall be taken between 6 and 10 in. below the surface of the rosin in the package. This sample shall not be broken up or pulverized, but kept in a single lump, and when the acid number, saponification number, unsaponifiable matter, petroleum ether insoluble matter, and ash are to be determined the stated quantity shall be obtained by breaking from the single lump small pieces having freshly exposed surfaces, avoiding powdering as much as possible. These precautions are necessary because of the tendency of rosin to oxidize very rapidly on the surface when exposed to the air.

METHODS OF TESTING

2. *Acid Number.*—Acid number shall be determined as follows:

Weigh 2 g. of the rosin. Transfer to a 300-ml. Erlenmeyer flask and add 50 ml. of neutral 95 per cent ethyl alcohol. Allow the rosin to dissolve in the alcohol at normal temperature or with the aid of heat and cool to room temperature. Titrate with 0.5 N sodium hydroxide solution using phenolphthalein as indicator. If necessary, dilute the solutions of the redder rosins with additional neutral alcohol, in order to obtain a sharp end-point. Calculate as the acid number the milligrams of KOH required to neutralize 1 g. of the rosin.

3. *Alcoholic Solution for Saponification.*—The alcoholic potassium hydroxide solution shall be prepared as follows:

Dissolve 58 g. of potassium hydrate "purified by alcohol" in 500 ml. of purified 95 per cent ethyl alcohol. Allow the solution to settle in a dark place. Draw off the clear solution or filter through an asbestos filter and make up to one liter with 95 per cent alcohol. The solution so prepared shall stand at least 20 hr. before it is standardized.

4. *Saponification Number.*—Saponification number shall be determined as follows:

Weigh 2 g. of the rosin. Transfer to a 300-ml. Erlenmeyer flask; add 50 ml. of neutral 95 per cent ethyl alcohol and 20 ml. of the alcoholic potassium hydroxide solution. Connect the flask to a reflux condenser and heat on a steam bath for 1 hr. Cool, add phenolphthalein as indicator, and titrate with 0.5 N H_2SO_4 or HCl, diluting the solution, if necessary, with neutral 95 per cent alcohol to obtain a sharp end-point. Run a blank, using the same quantities of solvent and alcoholic potassium hydroxide solution. From the difference between the quantities of acid required for the blank and the determination, calculate as the saponification number the milligrams of KOH required to saponify 1 g. of the rosin.

5. *Unsaponifiable Matter.*—Unsaponifiable matter shall be determined as follows:

(*a*) Weigh 5 g. of the rosin. Transfer to a 300-ml. Erlenmeyer flask and add 50 ml. of 95 per cent ethyl alcohol and 10 ml. of 30 per cent sodium hydroxide solution. Connect the flask with a reflux condenser and boil gently for 1 hr. Attach a condenser and collect 30 ml. of the distillate. On diluting this distillate with two volumes of water, a turbidity indicates the presence of light volatile oils. Light oils coming over with the alcohol distillate shall not be considered as "unsaponifiable matter."

(*b*) Transfer the contents of the flask after cooling to a 500-ml. glass-stoppered separatory funnel, rinsing the flask with water. Dilute with water to 200 ml. and add 100 ml. of ethyl ether, stopper, and shake for 1 minute. Allow the layers to separate sharply and clearly. Draw off all but a few drops of the aqueous layer into a second 500-ml. separatory funnel and repeat the process, using 50 ml. of ether. After thorough separation, draw off the aqueous portion into a 400-ml. beaker, then the ether solution into the first separatory funnel, rinsing down with a little water. Return the aqueous solution into the second separatory funnel and repeat the process of shaking-out with 50-ml. portions of ether until the ether layer is colorless, finally drawing the aqueous portion into the beaker and rinsing the ether into the first separatory funnel.

(*c*) Wash the combined ether solutions with 25-ml. portions of water until the water layer is neutral to phenolphthalein, drawing off water after each washing. Swirl the separatory funnel so as to bring the last drops of water down to the stopcock and draw off until the ether solution just fills the bore of the stopcock. Wipe out the stem of the separatory funnel with a bit of cotton on wire. Transfer the ether solution (portion-wise, if necessary) to a 300-ml. flask and distill until about 25 ml. remain. While still hot, drain the flask into a small weighed beaker or crystallizing dish, rinsing with a little ether. Evaporate the ether on a steam bath, cool the dish, and weigh. Do not heat after the odor of ether has gone. From the weight of this residue calculate as a percentage the unsaponifiable matter.

6. *Petroleum Ether Insoluble Matter.*—Matter insoluble in petroleum ether shall be determined as follows:

(*a*) Weigh 1 g. of freshly pulverized rosin into a tared 250-ml. glass or stoppered (a cork covered with tin foil may be used) Erlenmeyer flask. Add 100 ml. of petroleum ether (boiling point, 30 to 75 C.), stopper the flask and shake to prevent the rosin coalescing or adhering to the flask, then add an additional 50 ml. of petroleum ether, stopper and shake vigorously for about 5 minutes, or until any undissolved rosin is in a finely divided state and does not adhere to the flask. Allow the flask to stand over night at a temperature of 23 to 28 C., and filter the solution through a tared Gooch crucible, rinsing the flask with about 50 ml. of petroleum ether. Wipe the outside of the flask and crucible with a cloth wet with alcohol or acetone and dry in an oven at 95 to 100 C. for about 5 hr., cool and weigh. From the combined weights of the residue in the flask and in the crucible calculate the percentage of petroleum ether insoluble matter.

(*b*) The purpose of this test is to determine the degree of oxidation rather than the quantity of extraneous matter in the rosin. If the rosin is appreciably "dirty," determine the extraneous matter in accordance with the Standard

Method of Test for Determination of Toluol Insoluble Matter in Rosin (Chiefly Sand, Chips, Dirt and Bark) (A.S.T.M. Designation: D 269–30) of the American Society for Testing Materials,[1] and subtract the quantity found from the quantity of petroleum ether insoluble to obtain the true petroleum ether insoluble matter of the sample.

7. *Ash.*—Ash shall be determined as follows:

Weigh 5 g. of rosin into a porcelain crucible. Burn off the combustible matter slowly and ignite the residue until the ash is free from carbonaceous matter. Cool the crucible in a desiccator and weigh. Report the result as percentage of ash.

8. *Volatile Oils.*—As a rule, rosin contains a small amount of volatile oil, sometimes as much as 2 or 3 per cent in the case of the higher grades. The presence of this volatile oil may be indicated by a relatively low melting point or viscosity, by the tackiness of the rosin, and by its tendency to flow at room temperature.

To determine the percentage of volatile oil in rosin, place 100 or 200 g. of freshly broken lumps in a 1-liter distilling flask and distill with steam, receiving the distillate in a graduated cylinder. Measure exactly the volume of separated oil and calculate as percentage (by volume) of the rosin.

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[1] 1933 Book of A.S.T.M. Standards, Part II, p. 697.

APPENDIX II

PROPOSED METHOD OF TEST FOR VISCOSITY OF ROSIN

(Ring-and-Ball Method)[1]

1. *Viscosity.*—Rosin, like bituminous materials, has no true softening or melting point. As the temperature rises it passes from the solid to the liquid state while its viscosity is correspondingly lowered. This relation of physical state to viscosity makes it possible to evaluate rosin by a measurement of flow which is dependent upon viscosity. This can be done under arbitrarily standardized conditions. The Ring-and-Ball Method is one means of making such measurement.

NOTE.—This method follows essentially the Standard Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method) (A.S.T.M. Designation: D 36) of the American Society for Testing Materials,[2] as modified by the Bureau of Standards and described in Research Paper No. 142,[3] with such additional modifications as have so far been found to be desirable in adapting it to the requirements of an arbitrary viscosity method for rosin.

2. *Apparatus.*—The essential apparatus required shall consist of the following:

(*a*) *Ring.*—The brass ring shall conform to the following dimensions:

Depth	6.35 mm. ± 0.10 mm. ($\frac{1}{4}$ in.).
Inside diameter at bottom	15.88 mm. ± 0.10 mm. ($\frac{5}{8}$ in.).
Inside diameter at top	17.46 mm. ± 0.10 mm. ($\frac{11}{16}$ in.).
Outside diameter at bottom	19.0 mm. ± 0.1 mm. ($\frac{3}{4}$ in.).
Outside diameter at top	20.6 mm. ± 0.1 mm.

(*b*) *Ball.*—A steel ball, such as used in ball bearings, 9.53 mm. ($\frac{3}{8}$ in). in diameter weighing between 3.45 and 3.55 g.

(*c*) *Container.*—A glass vessel, capable of being heated, not less than 8.5 cm. ($3\frac{1}{3}$ in.) in diameter and not less than 10.5 cm. ($4\frac{1}{8}$ in.) in depth from the bottom of the flare. (600-ml. beaker, low form.)

(*d*) *Thermometer.*—For rosins having a viscosity end point below 80 C. the thermometer used shall be an A.S.T.M. Low Softening Point Thermometer conforming to the requirements of Section 3 (*d*) of the Standard Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method) (A.S.T.M. Designation: D 36) of the American Society for Testing Materials.[2] For rosins having a viscosity end point above 80 C. the thermometer used shall be an A.S.T.M. High Softening Point Thermometer conforming to the requirements of Section 8 of the Standard Method D 36.

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[1] Criticisms of this proposed method are solicited and should be directed to Mr. C. F. Speh, Secretary of Committee D-17 on Naval Stores, Pine Inst. of America, Barnett National Bank Building, Jacksonville, Fla.

[2] 1933 Book of A.S.T.M. Standards, Part II, p. 984.

[3] P. H. Walker, "The Ring and Ball Method of Test for Softening Point of Bituminous Materials, Resins, and Similar Substances," U. S. Bureau of Standards *Journal of Research*, Vol. 4, No. 2, p 195 (1930).

(*e*) *Support for Ring and Thermometer.*—Any convenient method for supporting the ring may be used provided it meets the following requirements: The ring must be supported in a substantially horizontal position; the top of the ring must be at least 7.6 cm. (3 in.) below the top of the container, and the bottom of the ring 2.5 ± 0.1 cm. (1 in.) above a horizontal plate which shall be approximately ½ in. above the bottom of the container; the distance from the center of the ring to thermometer bulb must be not more than 16.5 mm. (⅝ in.).

(*f*) *Ball Guide.*—A guide for centering the ball shall be used.[1]

3. *Preparation of Sample.*—The sample shall be prepared as follows:

Select pieces of the sample which have been freshly cut or broken out of larger lumps, and proceed with the examination immediately. Place in a small clean beaker about twice the amount of rosin as is necessary to fill the desired number of rings and heat *slowly*, preferably by standing the beaker in an oil bath, to the minimum temperature at which the rosin can be readily poured into the rings. Stir at intervals to avoid local overheating, using care not to incorporate air bubbles. The time between the beginning of the heating and the pouring of the sample into the rings should never exceed 10 minutes. Most rosins can be poured at about 120 C. Immediately before filling the rings, preheat them to approximately the temperature at which the rosin is to be poured. The rings, while being filled, should rest upon a brass plate which has been amalgamated to prevent the sample from adhering to it. After cooling, cut off the excess material cleanly with a slightly heated knife or spatula. Allow the sample to stand in the ring at least 30 minutes before proceeding with the test.

If it is necessary to prepare additional test samples, a fresh portion of the rosin shall be selected and heated in a clean beaker as previously described.

4. *Procedure.*—The viscosity shall be determined as follows:

(*a*) *Assembling.*—Fill the glass container to a depth of not less than 9 cm. (3.5 in.) with freshly boiled water that has been cooled to not less than 45.0 C. below the anticipated viscosity end point of the material under test. If the softening point is below 50 C. the water shall be cooled to approximately 5 C. Place the ball in the center of the upper surface of the material in the ring and at once suspend the support carrying the ring, ball, ball guide, and horizontal plate, so that the top of the ring is between 5 and 6 cm. (2 to 2.5 in.) below the surface of the water, and the thermometer is hanging approximately in the middle of the container with the center of its bulb on a level with the ring.

(*b*) *Heating.*—Apply heat in such a manner that the temperature of the water after the first three minutes shall be raised uniformly 5 C. per minute. The maximum permissible variation for any minute period after the first three shall be ±0.5 C. All tests in which the rate of rise in temperature exceeds these limits shall be rejected. To facilitate uniform heating it is advisable to place the burner midway between the center and the edge of the beaker away from the specimen.

(*c*) *End Point.*—Report as the end point the temperature indicated by the thermometer (adding or subtracting any certified corrections) at the instant the sample touches the horizontal plate. Duplicate determinations shall agree within 1.0 C.

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[1] See drawings of apparatus and assembly in "The Ring and Ball Method of Test for Softening Point of Bituminous Materials, Resins, and Similar Substances" by P. H. Walker, U. S. Bureau of Standards *Journal of Research*, Vol. 4, No. 2, p. 197 (1930).

REPORT OF COMMITTEE E-1

ON

METHODS OF TESTING

Studies which Committee E-1 on Methods of Testing has been making of various tests have reached a point where there is an increasing number of specific methods being prepared by the several sections and a number of recommendations covering standards and tentative standards appear in this report. The sections have been quite active during the year, a number of meetings having been held during the Spring Group Meetings of the Society in New York City. Committee E-1 has held two meetings: one during the 1932 annual meeting at Atlantic City, N. J., and one on April 29, 1933, in Philadelphia, Pa.

Two of the technical committees, namely, the Technical Committee on Mechanical Testing and the Technical Committee on Particle Size and Shape, have been reorganized so that the work can be handled more effectively by having a small advisory committee to coordinate and supervise the work being carried out in the individual sections. Mr. E. W. Dean has been appointed chairman of the Technical Committee on Volatility to succeed Mr. C. S. Reeve.

ACTIVITIES OF TECHNICAL COMMITTEES

Reports concerning the work during the year of the several technical committees are given below:

Technical Committee on Mechanical Testing (H. F. Moore, chairman):

Section on Tension Testing (R. L. Templin, chairman).—On the recommendation of this section revisions in the Tentative Methods of Tension Testing of Metallic Materials (E 8 - 27 T)were accepted for publication[1] by Committee E-10 on Standards at a meeting held on August 11, 1932. The methods in their revised form appear in the 1932 *Proceedings*.[2] On the recommendation of the section Committee E-1 now recommends that these tentative methods be referred to letter ballot of the Society for adoption as standard.

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[1] In submitting these revised tentative methods to Committee E-10 on Standards, Committee E-1 reported results of the letter ballot vote as follows: Of a total membership of 57, 31 members returned their ballots, of whom 22 voted affirmatively and 1 negatively.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 945 (1932); also 1932 Book of A.S.T.M. Tentative Standards, p. 1077.

Section on Compression Testing (M. F. Sayre, chairman).—This section has prepared a revision of the Tentative Methods of Compression Testing of Metallic Materials (E 9 – 27 T)[1] in order to bring these methods in accord with revisions of the tension methods made a year ago. It is recommended that the revised methods of compression testing, appended hereto,[2] be accepted by the Society for publication as tentative.

Section on Indentation Hardness (J. R. Townsend, chairman).—On the recommendation of this section Tentative Methods of Rockwell Hardness Testing of Metallic Materials (E 18 – 32 T) were accepted for publication[3] as tentative by Committee E-10 on Standards at a meeting held on August 11, 1932, and appear in the 1932 *Proceedings*.[4] The committee has received a number of comments in respect to these methods and is now at work on a revision which it is proposed to submit to Committee E-10 on Standards during the coming year to replace the present tentative methods.[5]

Section on Testing Thin Sheet Metals (C. H. Marshall, chairman).—Several years ago this section formulated requirements for test specimen for tension testing of thin sheet metals. These requirements which appear in the Tentative Methods of Tension Testing of Metallic Materials (E 8 – 32 T) are being recommended for adoption as standard. The section is now studying the correlation between various tests applied to thin sheet metals and the tension test. A round-table discussion on the Use of the Tension Test for Judging the Suitability of Sheet Material for Various Purposes is being sponsored by this section during the current annual meeting of the Society.

Section on Impact Testing (W. W. Werring, chairman).—The first draft of proposed tentative methods of impact testing (Charpy and Izod tests) has been prepared by this section and after further study the section plans to submit these methods in the near future to Committee E-1 for consideration.[6]

Section on Effect of Speed of Testing (P. G. McVetty, chairman).—This section is finding very wide divergence in testing speeds used in practice and very great difficulty in reconciling these differences.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 27, Part I, p. 1081 (1927); also 1932 Book of A.S.T.M. Tentative Standards, p. 1093.

[2] See p. 959.—ED.

[3] In submitting these tentative methods to Committee E-10 on Standards, Committee E-1 reported results of the letter-ballot vote as follows: Of a total membership of 57, 32 members returned their ballots, of whom 22 voted affirmatively and none negatively.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 961 (1932); also 1932 Book of A.S.T.M. Tentative Standards, p. 1098.

[5] The revised methods were accepted for publication as tentative and appear on p. 967. See Editorial Note, p. 450.—ED.

[6] The methods were accepted for publication as tentative and appear on p. 976. See Editorial Note, p. 450.—ED.

The section is also finding such wide differences between speed of head of testing machine and rate of strain of specimen that there is some doubt whether speed of head of testing machine is a reliable criterion of effect of speed in testing.

Section on Elastic Strength of Materials (F. B. Seely, chairman).—This section is receiving comment and criticism on the revised definitions of "yield strength" and "elastic limit" in the Tentative Definitions of Terms Relating to Methods of Testing (E 6 – 32 T) which were accepted for publication[1] by Committee E-10 on Standards at a meeting held on August 11, 1932. The definitions in their revised form appear in the 1932 *Proceedings*.[2] A number of requests have been received that there be tabulated values of limiting set to determine "yield strength" for different materials. This question will be taken up in cooperation with the various committees of the Society dealing with specific materials.

Section on Calibration of Testing Machines and Apparatus (H. F. Moore, chairman).—This section has prepared an extensive revision of the present Standard Methods of Verification of Testing Machines (E 4 – 27) and has recommended that these revised methods as appended hereto[3] be published by the Society as tentative to replace the present standard methods which are recommended to be withdrawn.

Section on Flexure Testing.—The flexure test is now being used to an increasing extent in the testing of various materials and in order to coordinate the various tests a new section on flexure testing is being organized under the chairmanship of Mr. H. F. Clemmer.

The Technical Committee on Mechanical Testing has cooperated with a committee of the Compressed Gas Manufacturers Association commenting on that association's requirements for the testing of material used in gas cylinders.

Technical Committee on Consistency, Plasticity, Etc. (E. C. Bingham, chairman):

Proposed definitions for the terms consistency and plasticity were published as information in the 1930 annual report of Committee E-1. Comments on these definitions have been solicited and the committee has now prepared the following definitions which are again published as information in order to elicit criticism and comment:

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[1] In submitting these revised tentative definitions to Committee E-10 on Standards, Committee E-1 reported results of the letter-ballot vote as follows: Of a total membership of 57, 32 members returned their ballots, of whom 26 voted affirmatively and 2 negatively.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 967 (1932); also 1932 Book of A.S.T.M. Tentative Standards, p. 1111.

[3] See p. 1013.—ED.

Consistency.—Consistency is that property of a material other than a gas by virtue of which it resists the stresses which produce permanent change of shape. Consistency is expressed by the three following flow-force relations:

Simple (Newtonian) Liquid.—When the ratio of flow to force is constant, the material is said to be a simple liquid.

NOTE 1.—The simple liquid under conditions of non-turbulent flow follows Newton's law, which may be written, $v = \phi F r$, where v is the velocity imparted by the stress F per unit area, to either of two parallel planes separated by the distance r, the space between the planes being filled with the liquid. The constant ϕ is known as the *fluidity* which is the reciprocal of the *viscosity.*

Solid.—Any body which requires a finite stress to produce a permanent deformation is a solid.

Non-Newtonian Liquid.—A body which yields permanently under very small stresses and yet is not a simple liquid, is known as a non-Newtonian liquid.

NOTE 2.—Gases have not been considered in framing the above definitions.

NOTE 3.—The term consistency may be used irrespective of whether the body is a liquid or a solid.

Plasticity.—Plasticity is that property of a solid by virtue of which it is permanently deformed when stressed above the yield value. This is a complex property and therefore cannot be represented quantitatively by a single numerical value. The factors which define plasticity are the yield value and the mobility.

Yield Value, θ.—The minimum stress required to produce a permanent deformation in a solid.

Mobility, μ.—The coefficient in the law of plastic flow, $v = \mu (F - \theta) r$, where v is the velocity imparted by the stress F per unit area, to either of two parallel planes separated by the distance r, the space between the planes being filled with the plastic material.

Attention is called to the fact that yield value is defined very similarly to the present definition for elastic limit. The latter definition is of course defined having in mind the principal mechanical tests and effort is being made to reconcile the usages of these terms and definitions.

Technical Committee on Particle Size and Shape (L. T. Work, chairman):

This technical committee sponsored a round-table discussion on Industrial Applications of Particle Size Measurements during the Regional Meeting of the Society held in New York City on March 8, 1933. Papers were presented on the following subjects:

Pigments, by G. S. Haslam, New Jersey Zinc Co., and George Hiers, National Lead Co.

Dusts, by Theodore Hatch, School of Public Health, Harvard University

Coal, by R. M. Hardgrove, Fuller-Lehigh Co.

Cement, by J. C. Pearson, Lehigh Portland Cement Co., and J. R. Dwyer, Bureau of Standards

Soils, by H. H. Hatch, Springfield (Mass.) Water Works

New Developments in Sieve and Testing, by A. A. Klein, Norton Co.

Proposed Standard for Sieves, by L. V. Judson, Bureau of Standards

Road and Concrete Aggregates, by D. A. Abrams, J. R. Dwyer and J. C. Pearson

Section on Sub-Sieve Sizes (G. S. Haslam, chairman).—With the 1930 report of Committee E-1 there was published as information a proposed method of analysis for the particle size distribution of sub-sieve size particulate substances. As a result of experience with this method and in the light of comments received this section has prepared a revision of the method, appended hereto,[1] which is recommended for publication as tentative.

Section on Coarse Screens (F. H. Jackson, chairman).—The Tentative Specifications for Round-Hole Screens for Testing Purposes (E 17 - 31 T)[2] submitted by this section in 1931 are being recommended for submission to letter ballot of the Society for adoption as standard.

Technical Committee on Thickness Measurement (W. E. Emley, chairman):

This technical committee has been reviewing the methods for determining thickness as prepared by Committees D-9 on Electrical Insulating Materials, D-11 on Rubber Products and D-13 on Textile Materials and has been endeavoring to harmonize conflicting recommendations.

A device for measuring thickness under extremely small pressure and to a precision of the order of 0.0001 in. has been built and tested.[3] A device for measuring the variation in the thickness of a sample with variation in the pressure used in measuring thickness has also been built and tested.[4] By means of this device curves can be plotted showing the relation between thickness and pressure as the load is increased or decreased. These curves show not only the thickness at a stated pressure, but also the compressibility and resilience of the material.

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[1] See p. 989.—ED.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 1032 (1931); also 1932 Book of A.S.T.M. Tentative Standards, p. 1075.

[3] W. L. Holt, "Screw Micrometer Gages for Rubber Specimens," U. S. Bureau of Standards *Journal of Research*, May, 1933.

[4] H. F. Schiefer, "Compressometer, An Instrument for Evaluating the Thickness, Compressibility and Compressional Resilience of Textiles and Similar Materials," U. S. Bureau of Standards *Journal of Research*, June, 1933.

These two devices may be considered as examples of the application of the principles which must underlie the design of any instrument (other than optical) for the measurement of thickness. It is evident that the thickness of a compressible material can be defined only in terms of the pressure used in measuring it.

All interested standing committees of the Society are urged to cooperate in the adoption of a single standard pressure to be used in measuring thickness.

Technical Committee on Interpretation and Presentation of Data (Anson Hayes, chairman):

This technical committee has been active during the past year. The Program Committee under the chairmanship of Mr. H. F. Dodge has made substantial progress in the formulation of a long range program having to do with the use of scientific methods in the collection, analysis, interpretation and presentation of data.

The principal effort of the technical committee has been directed to the preparation of a Manual on Presentation of Data. The technical committee was asked to prepare recommendations concerning the form of presenting test results that could be embodied in instructions to prospective authors of papers to be presented before the Society. The Manual embodies such recommendations for one general type of data—a series of observations of a single variable obtained under the same essential conditions—and discusses the importance of using efficient functions of the data in summarizing the essential information contained therein. The Manual is appended hereto.

In any standardization project or experimental investigation, the problem of interpretation and presentation of data cannot be isolated and treated as independent of the problem of collection of data. The goodness of the data and the use that can be made of them depends closely on the techniques used in gathering them and the conditions surrounding their accumulation. With this in mind, the committee has arranged for a general discussion of the problem of collection of standardization data at an open session at which the discussion will be opened by the following papers:

Quality Control in Practice Using Inspection Results, by S. M. Osborne and P. S. Olmstead

Planning for Collection of Standardization Data, by J. R. Townsend.[1]

Mention should also be made of a formal paper by Messrs. R. F. Passano and F. R. Nagley on the subject, "Consistent Data Showing the Influence of Water Velocity and Time on the Corrosion of Iron" being presented at this annual meeting.[2]

Special Committee on Neutralization Number:

Reference was made in the 1932 report of the committee to the cooperation between Committee D-2 on Petroleum Products and Lubricants and Committee D-9 on Electrical Insulating Materials in the study of tests for the neutralization number of oils. This joint committee has made a study of the methods in use, including the present Tentative Method of Test for Neutralization Number of Petroleum Products and Lubricants (D 188 – 27 T) and electrolytic methods. The committee found that additional information was required and accordingly the studies are being continued and round-robin tests are being conducted on various samples of oils.

The recommendations appearing in this report have been submitted to letter ballot of the committee, which consists of 59 members, with the following results:

Items	Affirmative	Negative	Not Voting
I. PROPOSED TENTATIVE STANDARDS			
Methods of Verification of Testing Machines	24	0	6
Method of Analysis for the Particle Size Distribution of Sub-Sieve Size Particulate Substances	16	1	12
II. REVISION OF TENTATIVE STANDARD			
Methods of Compression Testing of Metallic Materials (E 9 – 27 T)	19	0	11
III. ADVANCEMENT OF TENTATIVE STANDARDS TO STANDARD			
Methods of Tension Testing of Metallic Materials (E 8 – 32 T)	19	1	10
Specifications for Round-Hole Screens for Testing Purposes (E 17 – 31 T)	17	0	12
IV. WITHDRAWAL OF STANDARD			
Standard Methods of Verification of Testing Machines (E 4 – 27)	22	0	8

This report has been submitted to letter ballot of the committee, which consists of 59 members; 31 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

W. H. FULWEILER,
Chairman.

R. E. HESS,
Ex-officio Secretary.

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[1] *Proceedings* Am. Soc. Testing Mats., Vol. 33, Part II, p. 770 (1933).
Ibid., p. 387.

EDITORIAL NOTE

The proposed Tentative Methods of Verification of Testing Machines, a revision of the existing standard methods, and Tentative Methods of Analysis for the Particle Size Distribution of Sub-Sieve Size Particulate Substances were accepted for publication as tentative and appear on pages 1013 and 989, respectively.

The proposed revision of the Tentative Methods of Compression Testing of Metallic Materials was accepted. The methods in their revised form appear on page 959.

The Tentative Methods of Tension Testing of Metallic Materials and Specifications for Round-Hole Screens for Testing Purposes were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1933, and appear in the 1933 Book of A.S.T.M. Standards, Part I, page 949, and Part II, page 1242, respectively.

The withdrawal of the Standard Methods of Verification of Testing Machines was approved.

Recommendations to Committee E-10 on Standards.—Proposed Tentative Methods of Impact Testing of Metallic Materials were approved by the committee subsequent to the annual meeting and were accepted for publication as tentative on August 16, 1933, by Committee E-10 on Standards and appear on page 976.

A revision of the Tentative Methods of Rockwell Hardness Testing of Metallic Materials, referred to in the report, was accepted on August 16, 1933, by Committee E-10 on Standards. The methods in their revised form appear on page 967.

APPENDIX

REPORT OF COMMITTEE ON MANUAL ON PRESENTATION OF DATA (1933)

This Manual on Presentation of Data was prepared by the Manual Committee,[1] appointed by Mr. Anson Hayes, Chairman of the Technical Committee on Interpretation and Presentation of Data, of Committee E-1 on Methods of Testing, to make available some of the principles of efficient presentation of data and to recommend practices for the American Society for Testing Materials.

The purposes for which the Society was founded—the promotion of knowledge of the materials of engineering and the standardization of specifications, and the methods of testing—involve at every turn the utilization of quantitative data. Such data form an important part of the source material used in arriving at new knowledge, and in selecting standards of quality and methods of testing that are adequate, satisfactory, and economic, from the standpoints of the producer and the consumer. Four general aspects of any problem involving the use of data are indicated in the accompanying diagram. This manual deals specifically with the fourth—presentation—but discusses briefly some of the reasons why the problem of presentation cannot be isolated nad treated independently of the problems of collection and interpretation. As indicated below, attention is restricted to one of the several types of data that are gathered by individuals or committees and presented to the Society.

Broadly, the three general objects of gathering engineering data are to discover: (1) physical constants and frequency distributions, (2) relationships—both functional and statistical—between two or more variables, and (3) causes of observed phenomena. Under these general headings, the following more specific objects in the work of the American Society for Testing Materials may be cited: (*a*) to discover the distributions of quality characteristics of materials which serve as a basis for setting economic standards of quality, for comparing the relative merits of two or more materials for a particular use, for controlling quality at desired levels, for predicting what variations in quality may be expected in subsequently produced material; to discover the distributions of the errors of measurement for particular test methods, which serve as a basis for comparing the relative merits of two or more methods of testing, for specifying the precision of standard tests, for setting up economical testing and sampling procedures; (*b*) to discover the relationship between two properties of a material, such as density and tensile strength; and (*c*) to discover physical causes of the behavior of materials under particular service conditions; to discover the causes of non-conformance with specified standards in order to make possible the elimination of assignable causes and the attainment of economic control of quality.

The manual limits its discussion to data of the type falling under (1), with particular emphasis on the nature of the frequency distributions for physical properties of materials and for errors of measurement. Sections 1 to 36 consider the problem: Given a set of n numbers containing the whole of the information under consideration, to determine how much of the total information is contained in a few simple functions of the numbers. Sections 37 to 47 consider briefly the importance of using efficient functions to express that part of the total information which is essential to the intended use of the data.

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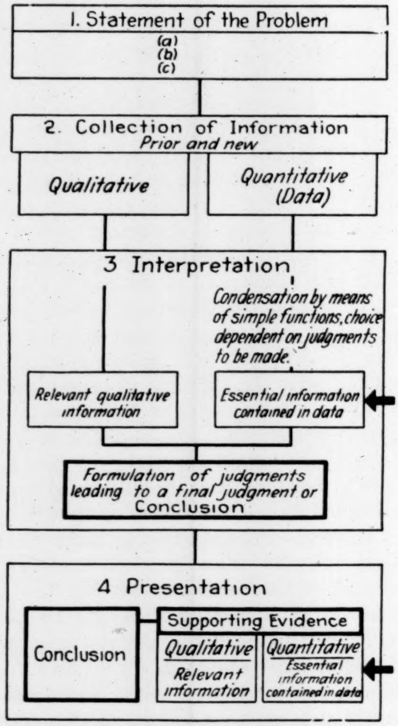
[1] Personnel of Manual Committee: Messrs. H. F. Dodge, Chairman, Member of Technical Staff, Bell Telephone Laboratories, Inc.; J. T. MacKenzie, Chief Chemist, American Cast Iron Pipe Co.; R. T. Webster, Quality Standards Branch, Western Electric Co.; and A. E. R. Westman, Director of Chemical Research, Ontario Research Foundation.


1. Statement of the Problem
(a)
(b)
(c)
2. Collection of Information
Prior and new
Qualitative
Quantitative (Data)
3 Interpretation
Condensation by means of simple functions, choice dependent on judgments to be made.
Relevant qualitative information
Essential information contained in data
Formulation of judgments leading to a final judgment or Conclusion
4 Presentation
Conclusion
Supporting Evidence
Qualitative
Relevant information
Quantitative
Essential information contained in data

Four Aspects of Any Problem Involving the Use of Data.

Arrows indicate items discussed particularly in this manual.

Acknowledgments.—The authors wish to acknowledge the ready cooperation of the Joint Committee on the Development of Applications of Statistics in Engineering and Manufacturing sponsored by the American Society for Testing Materials and The American Society of Mechanical Engineers,[1] and particularly their indebtedness to the Chairman of the Joint Committee, W. A. Shewhart, for his valuable and constructive criticisms. Acknowledgment is also made to Mr. Anson Hayes and other members of the Technical Committee on Interpretation and Presentation of Data for their assistance and suggestions.

H. F. Dodge, Chairman.
J. T. MacKenzie
R. T. Webster
A. E. R. Westman

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[1] See August, 1932, report of this committee, published in *Mechanical Engineering*, November, 1932.

MANUAL ON PRESENTATION OF DATA (1933)

INTRODUCTION

1. *Purpose.*—This manual discusses the application of statistical method to the problem of:

(*a*) condensing the information contained in a set of observations, and

(*b*) presenting the essential information in a concise form more readily interpretable than the unorganized mass of original data.

Attention will be directed particularly to quantitative information on measurable characteristics of materials and manufactured products. Such characteristics will be termed *quality characteristics.*

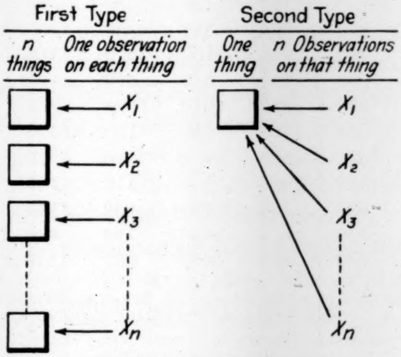

FIG. 1.—Two General Types of Data.

2. *Type of Data Considered.*—Consideration will be given to the treatment of a set of n observations of a single variable. Figure 1 illustrates two general types: (*a*) a series of n observations representing single measurements of the same quality characteristic of n similar things, and (*b*) a series of n observations representing n measurements of the same quality characteristic of one thing.

Data of the first type are commonly gathered to furnish information regarding the *distribution* of the quality of the material itself, having in mind possibly some more specific purpose, such as the establishment of a quality standard or the determination of conformance with a specified quality standard. Example: 100 observations of transverse strength, on 100 bricks of a given brand.

Data of the second type are commonly gathered to furnish information regarding the errors of measurement for a particular

TABLE I.—THREE GROUPS OF ORIGINAL DATA.

(*a*) TRANSVERSE STRENGTH OF 270 BRICKS OF A TYPICAL BRAND, LB. PER SQ. IN. TEST METHOD: STANDARD METHODS OF TESTING BRICK (COMPRESSION, FLEXURE, ABSORPTION) (A.S.T.M. DESIGNATION: C 67 – 31), 1931 SUPPLEMENT TO BOOK OF A.S.T.M. STANDARDS, P. 65. (DATA FROM A.S.T.M. MANUAL FOR INTERPRETATION OF REFRACTORY TEST DATA, P. 65 (1931).)

860	1320	820	1040	1000	1010	1190	1180	1080	1100	1130
920	1100	1250	1480	1150	740	1080	860	1000	810	1000
1200	830	1100	890	270	1070	830	1380	960	1360	730
850	920	940	1310	1330	1020	1390	830	820	980	1330
920	1070	1630	670	1150	1170	920	1120	1170	1160	1090
1090	700	910	1170	800	960	1020	1090	2010	890	930
830	880	870	1340	840	1180	740	880	790	1100	1260
1040	1080	1040	980	1240	800	860	1010	1130	970	1140
1510	1060	840	940	1110	1240	1290	870	1260	1050	900
740	1230	1020	1060	990	1020	820	1030	860	850	890
1150	860	1100	840	1060	1030	990	1100	1080	1070	970
1000	720	800	1170	970	690	1020	890	700	880	1150
1140	1080	990	570	790	1070	820	580	820	1060	980
1030	960	870	800	1040	820	1180	1350	1180	950	1110
700	860	660	1180	780	1230	950	900	760	1380	900
920	1100	1080	980	760	830	1220	1100	1090	1380	1270
860	990	890	940	910	1100	1020	1380	1010	1030	950
950	880	970	1000	990	830	850	630	710	900	890
1020	750	1070	920	870	1010	1230	780	1000	1150	1360
1300	970	800	650	1180	860	1150	1400	880	730	910
890	1030	1060	1610	1190	1400	850	1010	1010	1240	
1080	970	960	1180	1050	920	1110	780	780	1190	
910	1100	870	980	730	800	800	1140	940	980	
870	970	910	830	1030	1050	710	890	1010	1120	
810	1070	1100	460	860	1070	880	1240	940	860	

(*b*) WEIGHT OF COATING OF 100 SHEETS OF GALVANIZED IRON SHEETS, OZ. TEST METHOD: TRIPLE SPOT TEST OF STANDARD SPECIFICATIONS FOR ZINC-COATED (GALVANIZED) SHEETS (A.S.T.M. DESIGNATION: A 93 – 27), 1930 BOOK OF A.S.T.M. STANDARDS, PART I, P. 288. (DATA FROM LABORATORY TESTS.)

1.467	1.603	1.577	1.563	1.437
1.623	1.603	1.577	1.393	1.350
1.520	1.383	1.323	1.647	1.530
1.767	1.730	1.620	1.620	1.383
1.550	1.700	1.473	1.530	1.457
1.533	1.600	1.420	1.470	1.443
1.377	1.603	1.450	1.337	1.473
1.373	1.477	1.337	1.580	1.433
1.637	1.513	1.440	1.493	1.637
1.460	1.533	1.557	1.563	1.500
1.627	1.593	1.480	1.543	1.607
1.537	1.503	1.477	1.567	1.423
1.533	1.600	1.550	1.670	1.573
1.337	1.543	1.637	1.473	1.753
1.603	1.567	1.570	1.633	1.467
1.373	1.490	1.617	1.763	1.563
1.457	1.550	1.477	1.573	1.503
1.660	1.577	1.750	1.537	1.550
1.323	1.483	1.497	1.420	1.647
1.647	1.600	1.717	1.513	1.690

(*c*) BREAKING STRENGTH OF 10 TEST SPECIMENS FROM 10 COILS OF 0.104-IN. HARD-DRAWN COPPER WIRE, LB. TEST METHOD: STANDARD SPECIFICATIONS FOR HARD-DRAWN COPPER WIRE (A.S.T.M. DESIGNATION: B 1 – 27), 1930 BOOK OF A.S.T.M. STANDARDS, PART I, P. 619. (DATA FROM INSPECTION REPORT.)

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test method. Example: 50 micrometer measurements of the thickness of a test block.

The illustrative examples in the subsequent sections will be restricted to data of the first type.[1]

3. *Homogeneous Data.*—While the methods here given may be used to condense any set of observations, the results obtained by using them may be of little value from the standpoint of interpretation unless the data are good in the first place and satisfy certain requirements.

To be useful for inductive generalization, any set of observations that is treated as a single group for presentation purposes should represent a series of measurements, all made under essentially the same test conditions, on a material or product, all of which has been produced under essentially the same conditions.

If a given set of data consists of two or more subportions collected under different test conditions or representing material produced under different conditions, it should be considered as two or more separate subgroups of observations, each to be treated independently in the analysis. Merging of such subgroups, representing significantly different conditions, may lead to a condensed presentation that will be of little practical value. Briefly, any set of observations to which these methods are applied should be *homogeneous.*

In the illustrative examples of the following sections, each set of observations will be assumed to be homogeneous—possible observations from a common parent population.

ORIGINAL DATA

4. *Examples.*—Table I gives three typical sets of observations, each representing measurements of a single physical property. Consideration will be given to ways of arranging and condensing these data into a form better adapted for practical use.

5. *Ungrouped Frequency Distributions.*—The first step in organizing a set of observed values of a single variable is the arrangement of the values in ascending order of magnitude. Such an arrangement is termed a frequency distribution, and will be referred to in the

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[1] The quality of a material in respect to some particular characteristic, such as tensile strength, is a frequency distribution function, not a single-valued constant.

The variability in a group of observed values of such a quality characteristic is made up of two parts; variability of the material itself, and the errors of measurement. In some practical problems, the error of measurement may be large compared with the variability of the material; in others, the converse may be true. In any case, if one is interested in discovering the objective frequency distribution of the quality of the material, consideration must be given to correcting the data for errors of measurement.

See W. A. Shewhart, "Economic Control of Quality of Manufactured Product," pp. 379–385, D. Van Nostrand Co., Inc., New York City (1931).

TABLE II.—UNGROUPED FREQUENCY DISTRIBUTIONS IN TABULAR FORM.

(*a*) TRANSVERSE STRENGTH, LB. PER SQ. IN. (DATA OF TABLE I (*a*))

270	780	830	870	920	970	1020	1070	1100	1180	1310
460	780	830	880	920	980	1020	1070	1100	1180	1320
570	780	830	880	920	980	1020	1070	1100	1180	1330
580	790	840	880	920	980	1020	1070	1100	1180	1330
630	790	840	880	920	980	1020	1070	1110	1180	1340
650	800	840	880	930	980	1020	1070	1110	1180	1350
660	800	850	880	940	980	1020	1070	1110	1180	1360
670	800	850	890	940	990	1030	1080	1120	1190	1360
690	800	850	890	940	990	1030	1080	1120	1190	1380
700	800	850	890	940	990	1030	1080	1130	1190	1380
700	800	860	890	940	990	1030	1080	1130	1200	1380
700	800	860	890	950	990	1030	1080	1140	1220	1380
710	810	860	890	950	1000	1030	1080	1140	1230	1390
710	810	860	890	950	1000	1040	1080	1140	1230	1400
720	820	860	890	950	1000	1040	1090	1150	1230	1400
730	820	860	900	960	1000	1040	1090	1150	1240	1480
730	820	860	900	960	1000	1040	1090	1150	1240	1510
730	820	860	900	960	1000	1050	1090	1150	1240	1610
740	820	860	900	960	1010	1050	1100	1150	1240	1630
740	820	860	910	970	1010	1050	1100	1150	1250	2010
740	820	870	910	970	1010	1060	1100	1160	1260	
750	830	870	910	970	1010	1060	1100	1170	1260	
760	830	870	910	970	1010	1060	1100	1170	1270	
760	830	870	910	970	1010	1060	1100	1170	1290	
780	830	870	920	970	1010	1060	1100	1170	1300	

(*b*) WEIGHT OF COATING, OZ.
(DATA OF TABLE I (*b*))

1.323	1.457	1.513	1.567	1.620
1.323	1.457	1.513	1.567	1.623
1.337	1.460	1.520	1.570	1.627
1.337	1.467	1.530	1.573	1.633
1.337	1.467	1.530	1.573	1.637
1.350	1.470	1.533	1.577	1.637
1.373	1.473	1.533	1.577	1.637
1.373	1.473	1.533	1.577	1.647
1.377	1.473	1.537	1.580	1.647
1.383	1.477	1.537	1.593	1.647
1.383	1.477	1.543	1.600	1.660
1.393	1.477	1.543	1.600	1.670
1.420	1.480	1.550	1.600	1.690
1.420	1.483	1.550	1.603	1.700
1.423	1.490	1.550	1.603	1.717
1.433	1.493	1.550	1.603	1.730
1.437	1.497	1.557	1.603	1.750
1.440	1.500	1.563	1.607	1.753
1.443	1.503	1.563	1.617	1.763
1.450	1.503	1.563	1.620	1.767

(*c*) BREAKING STRENGTH, LB.
(DATA OF TABLE I (*c*))

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manual as the *ungrouped frequency distribution* of the data, to distinguish it from the grouped frequency distribution defined in Section 8. Table II presents ungrouped frequency distributions for the three sets of observations given in Table I.

Figure 2 shows graphically the distribution of Table I (*a*).

A glance at one of the tabulations of Table II gives some information not readily observed in the original data of Table I—such as the maximum, the minimum, and the median or middlemost value. Such arrangements are sometimes of value in the initial stages of analysis.

6. *Remarks.*—It is rarely desirable to present data in the manner of Table I or Table II. The mind cannot grasp in its entirety the meaning of so many numbers; furthermore, greater compactness is required for most of the practical uses that are made of data.

GROUPED FREQUENCY DISTRIBUTIONS

7. *Introduction.*—The information contained in a set of observations may be condensed merely by grouping. Such grouping involves some loss of information but is often useful in presenting engineering data.

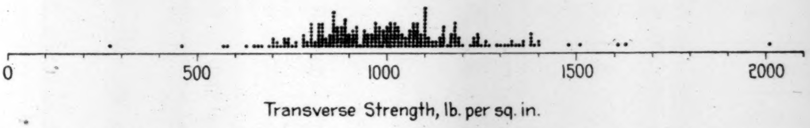

FIG. 2.—Showing Graphically the Ungrouped Frequency Distribution of a Set of Observations.

Each dot represents one brick, data of Table I (*a*).

8. *Definitions.*—A *grouped frequency distribution* of a set of observations is an arrangement which shows the frequency of occurrence of the values of the variable in ordered classes.

The interval, along the scale of measurement, of each ordered class is termed a *cell.*

The *frequency* for any cell is the number of observations in that cell.

The *relative frequency* for any cell is the frequency for that cell divided by the total number of observations.

Table III illustrates how the three sets of observations given in Table I may be organized into grouped frequency distributions. The recommended form of presenting tabular distributions is somewhat more compact, however, as shown in Table IV.

9. *Choice of Cell Boundaries.*—It is usually advantageous to make the cell intervals equal.

It is recommended that, in general, the *cell boundaries* be chosen half-way between two possible observations.[1] With this choice, the last digit of the cell boundary values will usually be a 5 in a further place of decimals than the values of the original data. For example, in Table III (*a*), observations were recorded to the nearest 10 lb., hence the cell boundaries were placed at 225, 375, etc., rather than at 220, 370, etc., or 230, 380, etc.

TABLE III.—THREE EXAMPLES OF GROUPED FREQUENCY DISTRIBUTIONS.

Showing cell midpoints and cell boundaries.

(*a*) TRANSVERSE STRENGTH, LB. PER SQ. IN. (DATA OF TABLE I (*a*))

CELL MID-POINT	CELL BOUND-ARIES	OBSERVED FRE-QUENCY
	225	
300		1
	375	
450		1
	525	
600		6
	675	
750		38
	825	
900		80
	975	
1050		83
	1125	
1200		39
	1275	
1350		17
	1425	
1500		2
	1575	
1650		2
	1725	
1800		0
	1875	
1950		1
	2025	
Total		270

(*b*) WEIGHT OF COATING, OZ. (DATA OF TABLE I (*b*))

CELL MID-POINT	CELL BOUND-ARIES	OBSERVED FRE-QUENCY
	1.275	
1.300		2
	1.325	
1.350		6
	1.375	
1.400		7
	1.425	
1.450		14
	1.475	
1.500		14
	1.525	
1.550		22
	1.575	
1.600		17
	1.625	
1.650		10
	1.675	
1.700		3
	1.725	
1.750		5
	1.775	
Total		100

(*c*) BREAKING STRENGTH, LB. (DATA OF TABLE I (*c*))

CELL MID-POINT	CELL BOUND-ARIES	OBSERVED FRE-QUENCY
	565	
567		1
	569	
571		6
	573	
575		0
	577	
579		1
	581	
583		1
	585	
587		0
	589	
591		0
	593	
595		1
	597	
Total		10

10. *Number of Cells.*—The number of cells in a frequency distribution should preferably be between 13 and 20.[2] If the number of observations is, say, less than 250, as few as 10 cells may be of use.

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[1] By choosing cell boundaries in this way, certain difficulties of classification and computation are avoided, see G. U. Yule, "An Introduction to the Theory of Statistics," pp. 79–82, Charles Griffin & Co., Ltd., London (1932).

[2] For a discussion of this point, see Shewhart, *op. cit.*, p. 69, and Yule, *op. cit.*, p. 79.

When the number of observations is less than 25, a frequency distribution of the data is generally of little value from a presentation standpoint, as for example the 10 observations in Table III (*c*). Other things being equal, the outline of a frequency distribution is more regular the smaller the number of cells. The tendency for a distribution to become more irregular as the number of cells is increased is indicated in Fig. 3.

11. *Methods of Classification.*—Figure 4 illustrates a convenient method of classifying observations into cells when the number of observations is not large. For each observation, a mark is entered in the proper cell. These marks are grouped in fives as the tallying proceeds.

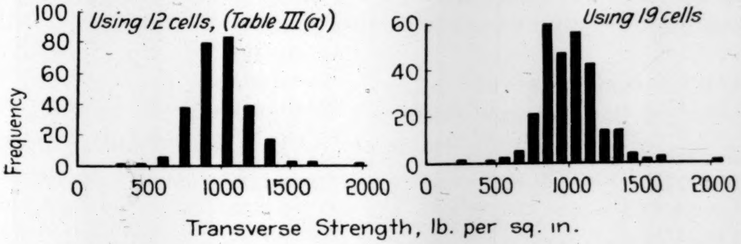

FIG. 3.—Illustrating Increased Irregularity with Larger Number of Cells.

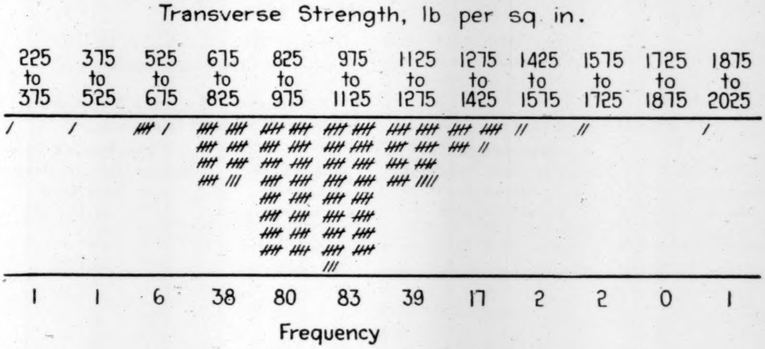

FIG. 4.—Method of Classifying Observations.
Data of Table I (*a*).

If the number of observations is, say, over 250, and accuracy is essential, it may be found advantageous to enter the observed values on cards, one to each observation. These may then be sorted into packs, each pack corresponding to a cell. By this means, the work of classification can be checked by making sure that no card has been wrongly sorted. When a large number of data are to be analyzed, the use of one of the several types of electrical machines for recording, sorting and counting the observations may be found economical.[1]

TABLE IV.—METHODS OF PRESENTING TABULAR FREQUENCY DISTRIBUTIONS.

(Data of Table I (*a*))

NOTE.—"Number of Observations" should be recorded with tables of relative frequencies.

FREQUENCIES		RELATIVE FREQUENCIES (Expressed in percentages)	
TRANSVERSE STRENGTH, LB. PER SQ. IN.	NUMBER OF BRICKS HAVING STRENGTH WITHIN GIVEN LIMITS	TRANSVERSE STRENGTH, LB. PER SQ. IN.	PERCENTAGE OF BRICKS HAVING STRENGTH WITHIN GIVEN LIMITS
225 to 375	1	225 to 375	0.4
375 to 525	1	375 to 525	0.4
525 to 675	6	525 to 675	2.2
675 to 825	38	675 to 825	14.1
825 to 975	80	825 to 975	29.6
975 to 1125	83	975 to 1125	30.7
1125 to 1275	39	1125 to 1275	14.5
1275 to 1425	17	1275 to 1425	6.3
1425 to 1575	2	1425 to 1575	0.7
1575 to 1725	2	1575 to 1725	0.7
1725 to 1875	0	1725 to 1875	0.0
1875 to 2025	1	1875 to 2025	0.4
Total................	270	Total...............	100.0
		Number of Observations = 270	

CUMULATIVE FREQUENCIES		CUMULATIVE RELATIVE FREQUENCIES (Expressed in percentages)	
TRANSVERSE STRENGTH, LB. PER SQ. IN.	NUMBER OF BRICKS HAVING STRENGTH LESS THAN GIVEN VALUES	TRANSVERSE STRENGTH, LB. PER SQ. IN.	PERCENTAGE OF BRICKS HAVING STRENGTH LESS THAN GIVEN VALUES
375	1	375	0.4
525	2	525	0.8
675	8	675	3.0
825	46	825	17.1
975	126	975	46.7
1125	209	1125	77.4
1275	248	1275	91.9
1425	265	1425	98.2
1575	267	1575	98.9
1725	269	1725	99.6
1875	269	1875	99.6
2025	270	2025	100.0
		Number of Observations = 270	

12. *Cumulative Frequency Distribution.*—For some purposes, the number of observations having a value "less than" or "greater

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[1] Information on mechanical tabulation is given by J. R. Riggleman and I. N. Frisbee, "Business Statistics," Chapter II and Appendix 2, pp. 597–601, McGraw-Hill Book Co., Inc., New York City and London (1932).

than" particular scale values is of more importance than the frequencies for particular cells. A table of such frequencies is termed a *cumulative frequency distribution.* The "less than" cumulative frequency distribution is formed by recording the frequency of the first cell, then the sum of the first and second cell frequencies, then the sum of the first, second, and third cell frequencies, and so on.

13. *Tabular Presentation.*—Methods of presenting tabular frequency distributions are shown in Table IV.[1] To make a table more comprehensive, relative frequencies may be listed as well as actual frequencies. If only relative frequencies are given, the table cannot be regarded as complete unless the total number of observations is recorded.

14. *Graphical Presentation.*—Using a convenient horizontal scale for values of the variable and a vertical scale for cell frequencies, frequency distributions may be reproduced graphically in several ways as shown in Fig. 5. The *frequency bar chart* is obtained by erecting a series of bars, centered on the cell midpoints, each bar having a

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[1] Confusion often arises from the failure to record correctly the cell boundary values in presentations of this type. For example, suppose strength measurements, covering a range of values from 2000 lb. to 4000 lb. were made to the nearest 10 lb., and the frequency distribution were presented thus:

Strength, lb.	Number of Specimens Within Given Limits
2000 to 2100	1
2100 to 2200	3
2200 to 2300	17
2300 to 2400	36
2400 to 2500	82
etc.	etc.

The table would give no clue as to how observed values of 2300, 2400, etc., had been classified. If all observed values of 2300 were placed in the cell 2300 to 2400, all observed values of 2400 in the cell 2400 to 2500, etc., the true cell boundaries would be 1995, 2095, 2195, etc. The proper method of presenting the distribution would be as follows:

Strength, lb.	Number of Specimens Within Given Limits
1995 to 2095	1
2095 to 2195	3
2195 to 2295	17
2295 to 2395	36
2395 to 2495	82
etc.	etc.

This method is recommended in preference to the following alternative that is sometimes used:

Strength, lb.	Number of Specimens at or Within Given Limits
2000 to 2090	1
2100 to 2190	3
2200 to 2290	17
2300 to 2390	36
2400 to 2490	82
etc.	etc.

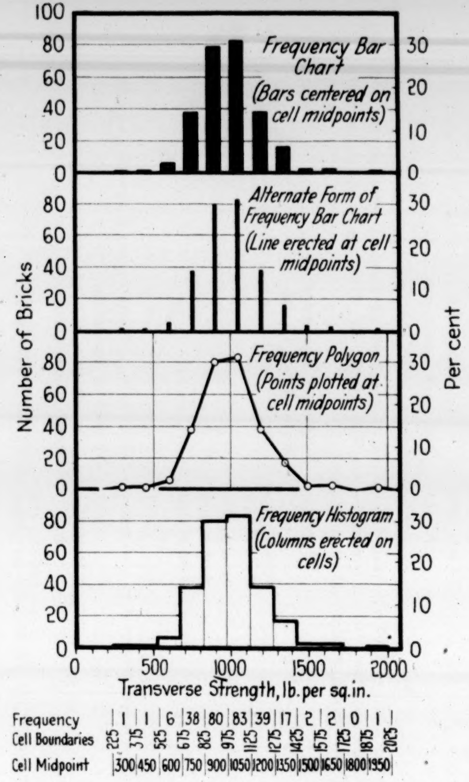

FIG. 5.—Graphical Presentations of a Frequency Distribution.

Data of Table I (*a*) as grouped in Table III (*a*).

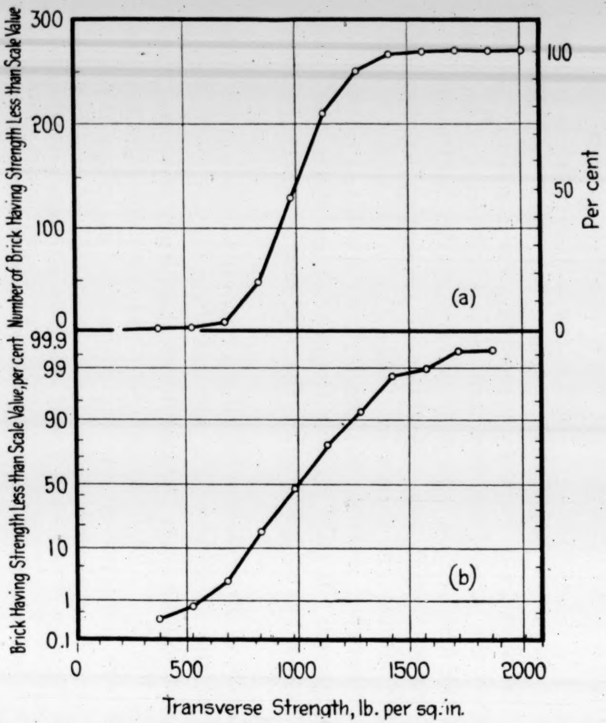

FIG. 6.—Graphical Presentations of a Cumulative Frequency Distribution.

Data of Table IV.

(*a*) Using arithmetic scale for frequency.
(*b*) Using probability scale for relative frequency.

height equal to the cell frequency. An alternate form of frequency bar chart may be constructed by using lines rather than bars. The distribution may also be shown by a series of points or circles representing cell frequencies plotted at cell midpoints. The *frequency polygon* is obtained by joining these points by straight lines. Each end point is joined to the base at the next cell midpoint to close the polygon.

Another form of graphical representation of a frequency distribution is obtained by placing along the graduated horizontal scale a series of vertical columns, each having a width equal to the cell width and a height equal to the cell frequency. Such a graph, shown at the bottom of Fig. 5, is called the *frequency histogram* of the distribution.

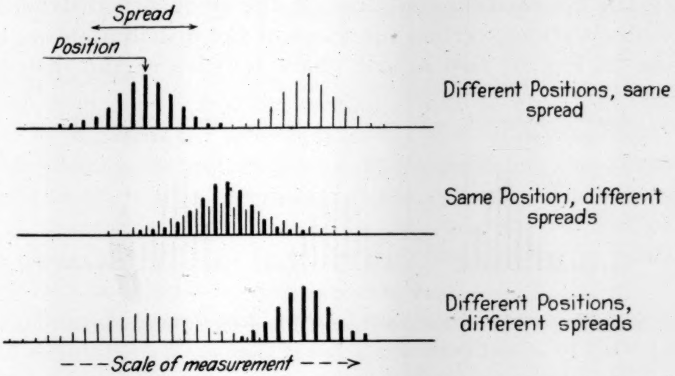

FIG. 7.—Illustrating Two Salient Characteristics of Distributions—Position and Spread.

In the histogram, the area enclosed by the steps represents frequency exactly, and the sides of the columns designate cell boundaries.

The same charts can be used to show relative frequencies by substituting a relative frequency scale, such as that shown at the right in Fig. 5. It is often advantageous to show both a frequency scale and a relative frequency scale. If only a relative frequency scale is given on a chart, the number of observations should be recorded.

Two methods of constructing cumulative frequency polygons are shown in Figure 6. Points are plotted at cell boundaries. The upper chart gives frequencies and relative frequencies plotted on an arithmetic scale. The lower chart shows relative frequencies plotted on a so-called "probability scale." Such graphs can be drawn to show the number of observations either "less than" or "greater than" the scale values.

15. *Remarks*.—The information contained in the data may be

summarized by presenting a tabular grouped frequency distribution, if the number of observations is large. A graphical presentation of a distribution makes it possible to visualize the nature and extent of the observed variation.

While some condensation is effected by presenting grouped frequency distributions, further reduction is necessary for most of the uses that are made of A.S.T.M. data. This need can be fulfilled by means of a few simple functions of the observed distribution, notably, the *average* and the *standard deviation.*

USEFUL FUNCTIONS OF A FREQUENCY DISTRIBUTION

16. *Introduction.*—In the problem of condensing and summarizing the information contained in the frequency distribution of a set of observations, certain functions of the distribution are useful. Referring to Fig. 7, two salient characteristics of the distribution are: (*a*) the position on the scale of measurement—the value about which the observations have a tendency to center, and (*b*) the spread or dispersion of the observations about the central value. A third characteristic of some interest, but of less importance, is the skewness or lack of symmetry—the extent to which the observations group themselves more on one side of the central value than on the other. (See Fig. 8.)

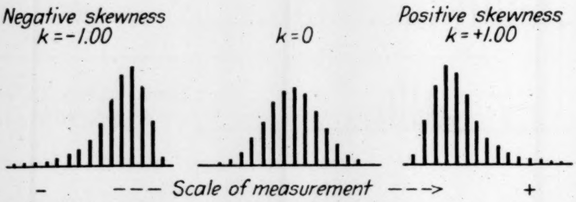

FIG. 8.—Illustrating a Third Characteristic of Frequency Distributions—Skewness—and Particular Values of Skewness k.

Several representative measures are available for describing these characteristics, but by far the most useful are the arithmetic mean, $\bar{X}$, the standard deviation, σ, and the skewness factor, k,—all algebraic functions of the observed values. Once the numerical values of these particular measures have been determined, the original data may usually be dispensed with and two or more of these values presented instead.

17. *Relative Frequency.*—The relative frequency, p, for stated limits on the scale of measurement is the fraction of the total number of observations lying within those limits.

In practical work, this function has its greatest usefulness as a measure of *fraction defective* or *fraction non-conforming*, in which case it is the fraction, p, of the total number of observations lying outside the specified limits (or beyond the specified limit).

18. *Arithmetic Mean.*—The arithmetic mean is the most widely used measure of central tendency.

The arithmetic mean, $\bar{X}$, of a set of n numbers, $X_1, X_2, \ldots X_n$, is the sum of the numbers divided by n; that is:

$$\bar{X} = \frac{X_1 + X_2 + \ldots + X_n}{n} = \frac{\sum\limits_{i=1}^{n} X_i}{n} \qquad (1)$$

where the expression $\sum\limits_{i=1}^{n} X_i$ means "the sum of all values of X, from X_1 to X_n, inclusive."

The term *average* and the symbol $\bar{X}$ will be used throughout the manual to represent the arithmetic mean of a set of numbers.

Considering the numbers as n equal particles, the average corresponds to the center of gravity of the system. The average of a series of observations is expressed in the same units of measurement as the observations; that is, if the observations are in pounds, the average is in pounds.

19. *Other Measures of Central Tendency.*—The *geometric mean*, of a set of n numbers, $X_1, X_2, \ldots X_n$, is the nth root of their product; that is,

$$\text{Geometric mean} = \sqrt[n]{X_1 X_2 \ldots X_n} \qquad (2)$$

$$\text{or, log (geometric mean)} = \frac{\log X_1 + \log X_2 + \ldots + \log X_n}{n} \qquad (3)$$

The geometric mean may be obtained by using the logarithms of the numbers rather than the numbers themselves. With this transformation[1] the method of computing the geometric mean is the same as that used for computing the average, $\bar{X}$.

The *median* of the frequency distribution of n numbers is the middlemost value.

The *mode* of the frequency distribution of n numbers is the value which occurs most frequently.

20. *Standard Deviation.*—The standard deviation is the most useful measure of dispersion for the problems considered in this manual.

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[1] The distribution of some quality characteristics is such that a transformation, using logarithms of the observed values, gives a substantially normal distribution. When this is true, the transformation is distinctly advantageous for (in accordance with Section 32) much of the total information can be presented by two functions, the geometric mean, and the standard deviation, σ, of the logarithms of the observed values. The problem of transformation is, however, a complex one that is beyond the scope of this manual.

The standard deviation, σ, of a set of n numbers, $X_1, X_2, \ldots X_n$, is the square root of the average of the squares of the deviations of the numbers from their average, $\bar{X}$; that is,

$$\sigma = \sqrt{\frac{(X_1 - \bar{X})^2 + (X_2 - \bar{X})^2 + \ldots + (X_n - \bar{X})^2}{n}} = \sqrt{\frac{\sum\limits_{i=1}^{n} (X_i - \bar{X})^2}{n}} \ldots (4)$$

Stated another way, it is root-mean-square (r.m.s.) deviation of the numbers from their average, $\bar{X}$.

Equation 5, derived from Eq. 4, is more convenient to use in computations.

$$\sigma = \sqrt{\frac{X_1^2 + X_2^2 + \ldots + X_n^2}{n} - \bar{X}^2} = \sqrt{\frac{\sum\limits_{i=1}^{n} X_i^2}{n} - \bar{X}^2} \ldots\ldots\ldots\ldots (5)$$

With this equation, the standard deviation is obtained by dividing the sum of the squares of the numbers by n, subtracting the square of their average, and extracting the square root.

In the language of mechanics, the standard deviation is "the radius of gyration of a set of n equal particles, with respect to a given centroidal axis."[1] The standard deviation of any series of observations is expressed in the same units of measurement as the observations, that is, if the observations are in pounds, the standard deviation is in pounds.

21. *Other Measures of Dispersion.*—The *coefficient of variation, v,* of a set of n numbers, is the ratio of their standard deviation, σ, to their average, $\bar{X}$, expressed as a percentage. It is given by:

$$v = 100 \frac{\sigma}{\bar{X}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

The coefficient of variation is an adaptation of the standard deviation which was developed by Prof. Karl Pearson to express the variability of a set of numbers on a relative scale rather than on an absolute scale. It is thus a pure number.

The *average deviation* of a set of n numbers, $X_1, X_2, \ldots X_n$, is the average of the absolute values of the deviations of the numbers from their average, $\bar{X}$; that is,

$$\text{Average deviation} = \frac{\sum\limits_{i=1}^{n} |X_i - \bar{X}|}{n} \ldots\ldots\ldots\ldots\ldots\ldots (7)$$

where the symbol | | represents the absolute value of a quantity.

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[1] *H. L. Rietz,* "Mathematical Statistics," p. 20, Open Court Publishing Co., Chicago (1917).

The simplest measure of dispersion of the frequency distribution of n numbers is the *range*—the difference between the largest number and the smallest number.

The *variance*, σ^2, of a set of n numbers is the average of the sum of the squares of the deviations of the numbers from their average, $\overline{X}$; that is,

$$\sigma^2 = \frac{1}{n} \sum_{i=1}^{n} (X_i - \overline{X})^2 \qquad (8)$$

As can be seen from Eqs. 4 and 8, the standard deviation is the square root of the variance.

TABLE V.—COMPUTATION OF AVERAGE AND STANDARD DEVIATION.

(Data of Table I (*c*))

Test Specimen	Breaking Strength, X, lb.	Square of Breaking Strength, X^2
1	578	334 084
2	572	327 184
3	570	324 900
4	568	322 624
5	572	327 184
6	570	324 900
7	570	324 900
8	572	327 184
9	596	355 216
10	584	341 056
$n = 10$	Sum 5752	3 309 232
Divide by $n = 10$	$\overline{X} = 575.2$	330 923.2
Square of $\overline{X}$		330 855.04
Subtract	Difference $= \sigma^2 =$	68.16
Extract square root	$\sigma =$	8.26

$$\text{Average} = \overline{X} = \frac{5752}{10} = 575.2 \text{ lb.}$$

$$\text{Standard deviation} = \sigma = \sqrt{\frac{3\,309\,232}{10} - (575.2)^2} = 8.26 \text{ lb.}$$

22. *Skewness k.*—In our problem, the most useful measure of the lopsidedness of a frequency distribution is skewness k.

The skewness k, of a set of n numbers, $X_1, X_2, \ldots X_n$, is defined by the expression:

$$k = \frac{\sum_{i=1}^{n} (X_i - \overline{X})^3}{n\sigma^3} \qquad (9)$$

This measure of skewness is a pure number and may be either positive or negative. For a symmetrical distribution, k is zero. In general,

TABLE VI.—ILLUSTRATING SIMPLIFIED METHOD OF COMPUTING AVERAGE AND STANDARD DEVIATION.

Computation Steps			Original Data		Subtract $A = 5000$		Subtract $A = 5600$		Subtract $A = 5600$ and Divide by $m = 10$	
			Original Number	Square	Number Minus A	Square	Number Minus A	Square	Number Minus A, Divided by m	Square
			X	X^2	X	X^2	X	X^2	X	X^2
			5 690	32 376 100	690	476 100	90	8 100	9	81
			5 670	32 148 900	670	448 900	70	4 900	7	49
			5 670	32 148 900	670	448 900	70	4 900	7	49
			5 680	32 262 400	680	462 400	80	6 400	8	64
			5 670	31 584 400	620	384 400	20	400	2	4
			5 630	31 696 900	630	396 900	30	900	3	9
			5 670	32 148 900	670	448 900	70	4 900	7	49
			5 670	32 148 900	670	448 900	70	4 900	7	49
			5 690	32 376 100	690	476 100	90	8 100	9	81
			5 680	32 262 400	680	462 400	80	6 400	8	64
Total first column,	(*a*) $= \Sigma X$	=	56 670		6670		670		67	
Total second column,	(*b*) $= \Sigma X^2$	=		321 153 900		4 453 900		49 900		499
Divide (*a*) by $n = 10$,	(*c*) $= \dfrac{\Sigma X}{10}$	=	5 667		667		67		6.7	
Divide (*b*) by $n = 10$,	(*d*) $= \dfrac{\Sigma X^2}{10}$	=		32 115 390		445 390		4 990		49.9
Add A to (*c*),	(*e*) $= A + \dfrac{\Sigma X}{10}$	=	$\overline{X} = 5\,667$		$\overline{X} = 5667$		$\overline{X} = 5667$		$\overline{X} = 5667$[a]	
Square (*c*),	(*f*) $= \left(\dfrac{\Sigma X}{10}\right)^2$	=		32 114 889		444 889		4 489		44.89
Subtract (*f*) from (*d*),	(*g*) $= \dfrac{\Sigma X^2}{10} - \left(\dfrac{\Sigma X}{10}\right)^2$	=		501		501		501		5.01
Extract square root of (*g*),	(*h*) $= \sqrt{\dfrac{\Sigma X^2}{10} - \left(\dfrac{\Sigma X}{10}\right)^2}$	=		$\sigma = 22.4$		$\sigma = 22\ 4$		$\sigma = 22.4$		2.24
Multiply (*h*) by $m = 10$,	(*i*) $= m\sqrt{\dfrac{\Sigma X^2}{10} - \left(\dfrac{\Sigma X}{10}\right)^2}$	=								$\sigma = 22.4$

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[a] Multiply (*c*) by $m = 10$ and add A, $m\dfrac{\Sigma X}{10} + A$.

for a non-symmetrical distribution, k is negative if the long tail of the distribution extends to the left, the negative direction on the scale of measurement, and is positive if the long tail extends to the right, the positive direction on the scale of measurement. Figure 8 shows three unimodal distributions with different values of k.

23. *Remarks.*—Of the many measures that are available for describing the salient characteristics of a frequency distribution, the average, $\bar{X}$, the standard deviation, σ, and the skewness, k, are particularly useful for summarizing the information contained therein.

METHODS OF COMPUTATION

24. *Computation of Average and Standard Deviation.*—The average and standard deviation can be computed by using Eqs. 1 and 5. The method of computation is illustrated in Table V, using the data of Table I (c). Tables of squares are useful in carrying out these computations.[1] Square roots may be found to a satisfactory degree of accuracy for most practical purposes by using columns of squares and interpolating to find the square roots desired.

The standard deviation of any set of numbers remains the same if a constant number is added to or subtracted from each of the original numbers. Table VI illustrates how this fact can be utilized to reduce the magnitude of the numbers dealt with in making computations. The subtraction of the constant A is equivalent to making computations with respect to an arbitrary origin, A. The computation work can readily be checked by using a second value of A. The last two columns of Table VI indicate how the arithmetic may be further simplified by dividing the original numbers by a constant, m.

25. *Short Method of Computation When n Is Large.*—When the number, n, of observations is large, the computation work can be simplified considerably by making use of the grouped frequency distribution of the observations. Table VII shows a convenient form to use in computing the average, the standard deviation, and the skewness k. With this method, an arbitrary origin, A, is used and deviations from this origin are expressed in cells rather than in units of the scale of measurement. The equations for the average,

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[1] Calculating machines, if available, will be found of great aid in reducing the time of computation. Complete tables are given in Barlow's "Tables of Squares, Cubes, Square-Roots, Cube-Roots, and Reciprocals of all Integer Numbers up to 10,000," E. and F. N. Spon, London, (1930).

TABLE VII.—FORM FOR COMPUTING $\overline{X}$, σ AND k BY THE SHORT METHOD.

(Data of Table I (*a*))

Cell No.	Cell Mid-point	Cell Boundary	Deviation in Cells from A, x	Observed Frequency, y	yx	yx²	yx³	Relative Frequency
		225						
0	300	375	0	1	0	0	0	0.4
1	450	525	1	1	1	1	1	0.4
2	600	675	2	6	12	24	48	2.2
3	750	825	3	38	114	342	1 026	14.1
4	900	975	4	80	320	1280	5 120	29.6
5	1050	1 125	5	83	415	2 075	10 375	30.7
6	1200	1 275	6	39	234	1 404	8 424	14.5
7	1350	1 425	7	17	119	833	5 831	6.3
8	1500	1 575	8	2	16	128	1 024	0.7
9	1650	1 725	9	2	18	162	1 458	0.7
10	1800	1 875	10	0	0	0	0	0.0
11	1950	2 025	11	1	11	121	1 331	0.4
12								
13								
14								
15								
16								
17								
18								
19								
	Σ			Σy 270	Σyx 1 260	Σyx² 6370	Σyx³ 34 638	100.0

A = Mid point of cell No 0 = 300

m = Number of units per cell = 150

$n = \Sigma y$ = Number of observations = 270

Computation Factors for $\overline{X}$ and σ

$(a) = \dfrac{\Sigma yx}{\Sigma y} = \dfrac{1260}{270} = 4.666667$

$(b) = \dfrac{\Sigma yx^2}{\Sigma y} = \dfrac{6370}{270} = 23.592593$

$(c) = (a)^2 = 21.777781$

$(d) = (b) - (c) = 1.814812$

$(e) = (\sqrt{(d)})^3 = (1.347150)^3 = 2.444825$

Computation Factors for k

$(f) = \dfrac{\Sigma yx^3}{\Sigma y} = \dfrac{34\,638}{270} = 128.288888$

$(g) = 2(a)^3 = 203.259303$

$(h) = (f) + (g) = 331.548191$

$(i) = 3(a)(b) = 330.296325$

$(j) = (h) - (i) = 1.251866$

$\overline{X} = A + m(a) = 300 + 150(4.666667 = 1000.0$

$\sigma = m\sqrt{(d)} = 150(1.347150) = 202.07$

$k = \dfrac{(j)}{(e)} = \dfrac{1.251866}{2.444825} = 0.512$

$\overline{X}$, the standard deviation, σ, and the skewness k, of a grouped frequency distribution are:

$$\overline{X} = A + m\frac{\Sigma yx}{n} \quad \text{(10)}$$

$$\sigma = m\sqrt{\frac{\Sigma yx^2}{n} - \left(\frac{\Sigma yx}{n}\right)^2} \quad \text{(11)}$$

$$k = \frac{\dfrac{\Sigma yx^3}{n} - 3\left(\dfrac{\Sigma yx}{n}\right)\left(\dfrac{\Sigma yx^2}{n}\right) + 2\left(\dfrac{\Sigma yx}{n}\right)^3}{\left[\dfrac{\Sigma yx^2}{n} - \left(\dfrac{\Sigma yx}{n}\right)^2\right]^{3/2}} \quad \text{(12)}$$

where A = arbitrary origin,
m = the cell interval in units of the scale of measurement,
y = observed cell frequency, and
x = deviation in cells from A.

Table VII shows the computations for the data given in Table I (*a*). As will be noted, the work is simplified by making use of computation factors that are expressed in terms of the column totals, Σy, Σyx, Σyx^2 and Σyx^3.

26. *Remarks.*—The exact values of $\overline{X}$, σ, and k can, of course, be found by using Eqs. 1, 5, and 9, but the computation work may require an excessive amount of time when the number of observations is large. The short method of Section 25 introduces certain errors of grouping, since it assumes that all observations in each cell have a value equal to that of the cell midpoint. It is believed, however, that the short method is satisfactory for most practical purposes and that the errors introduced by grouping are not, in general, of sufficient importance to warrant the use of correction factors.[1]

For the data of Table I (*a*), the errors introduced by grouping in the short method are indicated in the following tabulation:

	EXACT VALUE	VALUE FOUND BY SHORT METHOD
Average, $\overline{X}$	999.8	1000.0
Standard deviation, σ	201.51	202.07

AMOUNT OF INFORMATION CONTAINED IN p, $\overline{X}$, σ, AND k.

27. *Introduction.*—In this section, the total information contained in a series of observations of a single variable is defined, and consideration is given to how much of the total information may be made available by presenting a few simple functions of the data—disregarding for the moment what uses are to be made of the data.

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[1] See Shewhart, *op. cit.*, pp. 78–79.

For present purposes, the *total information* will be defined as that contained in the original set of numbers arranged in ascending order of magnitude, that is, the ungrouped frequency distribution.[1] (See Table II.)

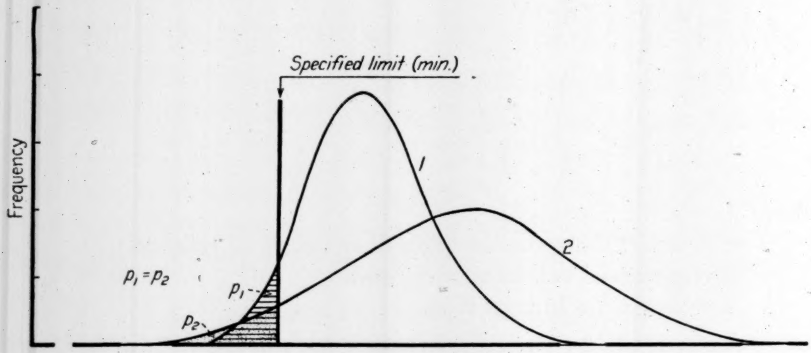

FIG. 9.—Totally Different Distributions May Have the Same Value of p—Fraction of Total Observations Below Specified Limit.

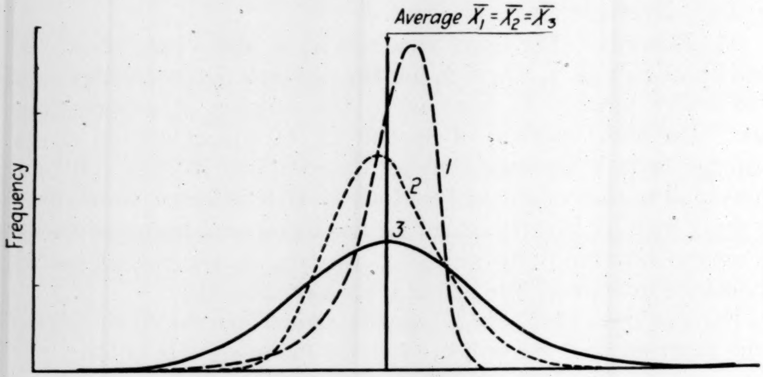

FIG. 10.—Totally Different Distributions May Have the Same Average.

28. *The Problem.*—Given a set of n observations

$$X_1, X_2, X_3, \ldots X_n,$$

of some quality characteristic, how can we present concisely information by means of which the observed distribution can be closely approximated, that is, so that the percentage of the total number, n, of observations lying within any stated interval from, say, $X = a$ to $X = b$, can be approximated?

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[1] The concept of the ungrouped frequency distribution as giving the total information is set forth by Shewhart, *op. cit.*, Chapter VIII. While this concept will be held in this manual, it should be pointed out that other viewpoints have been used. For example, R. A. Fisher considers the whole or total information contained in a set of numbers from the viewpoint of estimation—that is, estimating the central tendency, dispersion, etc., of the universe from which the observed set of observations is considered a random sample.

The total information can be presented only by giving all of the observed values. It will be shown, however, that much of the total information is contained in a few simple functions—notably the average, $\bar{X}$, the standard deviation, σ, and the skewness, k.

29. *Several Values of p.*—By presenting, say, 10 to 20 values of relative frequency, p, corresponding to stated cell intervals and also the number, n, of observations, it is possible to give practically all of the total information in the form of a tabular grouped frequency distribution. If the ungrouped distribution has any peculiarities, however, the choice of cells may have an important bearing on the amount of information lost by grouping.

30. *Single value of p.*—If we present but a single value of relative frequency, p, such as the fraction of the total number of observed values falling outside of a specified limit and also the number, n, of observations, the portion of the total information presented is very small. This follows from the fact that totally dissimilar distributions may have identically the same value of p as indicated in Fig. 9.

31. *Average, $\bar{X}$, Only.*—If we present merely the average, $\bar{X}$, and number, n, of observations, the portion of the total information presented is very small. Totally dissimilar distributions may have identically the same value of X, as illustrated in Fig. 10.

In fact, no single one of the four functions p, $\bar{X}$, σ, or k presented alone is capable of giving much of the total information in the original distribution. Only by presenting two or three of these functions can a fairly complete description of the distribution be made.

32. *Average, $\bar{X}$, and Standard Deviation, σ.*—These two functions contain some information even if nothing is known about the functional form of the observed distribution, and contain much information when certain conditions are satisfied, as discussed below.

With no reservations whatsoever, we may say that the presentation of $\bar{X}$ and σ, together with the number, n, of observations, gives the following information:

More than $(1 - \frac{1}{t^2})$ of the total number, n, of observations lie within the closed range $\bar{X} \pm t\sigma$ (where t is not less than 1). This is Tchebycheff's theorem and is shown graphically in Fig. 11. The theorem holds true of *any* set of finite numbers regardless of how they were obtained. Thus if $\bar{X}$ and σ are presented, we may say at once that more than 75 per cent of the numbers lie within the range $\bar{X} \pm 2\sigma$; stated in another way, less than 25 per cent of the numbers

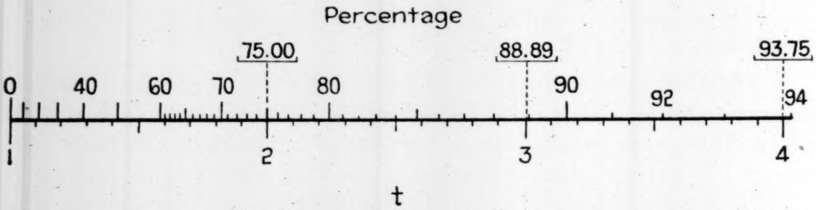

FIG. 11.—The Percentage of the Total Observations Lying Within the Range $\overline{X} \pm t\sigma$, Always Exceeds the Value Given on This Chart.

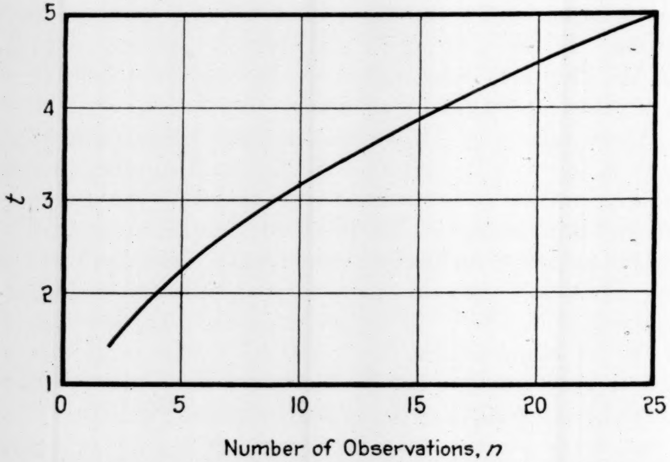

FIG. 12.—Values of t, Such That *All* Observations Lie Within the Range, $\overline{X} \pm t\sigma$.

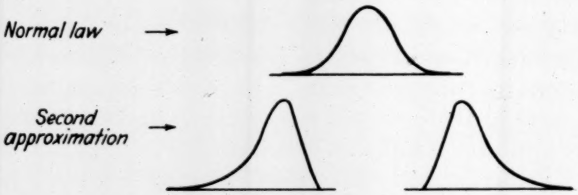

FIG. 13.—A Frequency Distribution for Observations Obtained Under Controlled Conditions Will Usually Have an Outline That Conforms with One of These General Patterns.

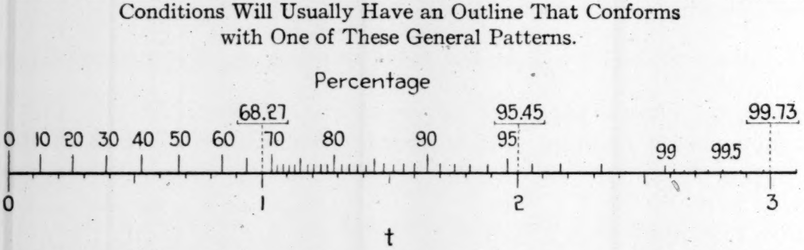

FIG. 14.—Approximate Percentage of Total Observations Lying Within the Range $\overline{X} \pm t\sigma$.

For data obtained under controlled conditions.

differ from $\bar{X}$ by more than 2σ. Likewise, more than 88.9 per cent lie within the range $\bar{X} \pm 3\sigma$, etc. From this theorem we also have the rule that if $n = 4$, all observations fall within $\bar{X} \pm 2\sigma$, if $n = 10$, all observations fall within $\bar{X} \pm 3.15\sigma$, etc., as shown in Fig. 12. This rule is useful particularly when n is small. Table VIII indicates the conformance with Tchebycheff's theorem of the three sets of observations given in Table I.

To obtain estimates of just what percentages of the total number of observations lie within given limits, as contrasted with minimum percentages within those limits (given above by Tchebycheff's theorem), requires additional information of a restrictive nature. If we present $\bar{X}$, σ and n, and are able to add the information "data obtained under controlled conditions," then it is possible to make such estimates satisfactorily for limits spaced equally above and below $\bar{X}$.

NOTE.—What is meant technically by "controlled conditions" is discussed by Shewhart, *op. cit.*, and is beyond the scope of this manual. Among other things, the concept of control includes the idea of *homogeneous data*—a set of observations resulting from measurements made under the same essential conditions and representing material produced under the same essential conditions. It is sufficient for present purposes to point out that if data are obtained under "controlled conditions," the form of curve which will best represent the observed frequency distribution may, for most practical purposes, be assumed to be that defined either by the Normal Law or by the Second Approximation illustrated in Fig. 13.

Thus the phrase "data obtained under controlled conditions" is taken to be the equivalent of the more mathematical assertion that "the functional form of the distribution may be represented by either the Normal Law equation or the Second Approximation equation (first two terms of the Gram-Charlier series)." However, conformance of the shape of a frequency distribution with one of these two curves should, by no means, be taken as a sufficient criterion for control.

For controlled conditions, the percentage of the total observations lying within the range $\bar{X} \pm t\sigma$ may be estimated from the chart of Fig. 14, which is based on the Normal Law integral. The approximation may be expected to be better the larger the number of observations. Table IX compares the observed percentages of the total number of observations lying within several symmetrical ranges about $\bar{X}$ with those estimated from a knowledge of $\bar{X}$ and σ, for the three sets of observations given in Table I.

33. *Average, $\bar{X}$, Standard Deviation, σ, and Skewness k.*—The presentation of k in addition to $\bar{X}$ and σ contributes very little from the viewpoint of presenting the total information, unless we are able to give some qualitative information in the manner outlined in Section 32. For data obtained "under controlled conditions," the presentation of k in addition to $\bar{X}$ and σ contributes something,

TABLE VIII.—COMPARISON OF OBSERVED PERCENTAGES AND THEORETICAL MINIMUM PERCENTAGES OF THE TOTAL OBSERVATIONS LYING WITHIN GIVEN RANGES.

Range, $\bar{X}$, plus or minus	Theoretical Percentages of Total Observations Lying Within Given Ranges	Observed Percentages		
		Data of Table I (*a*) ($n = 270$)	Data of Table I (*b*) ($n = 100$)	Data of Table I (*c*) ($n = 10$)
2.0 σ	more than 75.0	96.7	94	90
2.5 σ	more than 84.0	97.8	100	90
3.0 σ	more than 88.9	98.5	100	100

Data of Table I(*a*), $\bar{X} = 1000$, $\sigma = 202$
Data of Table I(*b*), $\bar{X} = 1.535$, $\sigma = 0.105$
Data of Table I(*c*), $\bar{X} = 575.2$, $\sigma = 8.26$

TABLE IX.—COMPARISON OF OBSERVED PERCENTAGES AND THEORETICAL ESTIMATED PERCENTAGES OF THE TOTAL OBSERVATIONS LYING WITHIN GIVEN RANGES.

Range, $\bar{X}$, plus or minus	Theoretical Estimated Percentages of Total Observations Lying Within Given Ranges	Observed Percentages		
		Data of Table I (*a*) ($n = 270$)	Data of Table I (*b*) ($n = 100$)	Data of Table I (*c*) ($n = 10$)
0.6745 σ	50.0	52.2	54	70
1.0 σ	68.3	76.3	72	80
1.5 σ	86.6	89.3	84	90
2.0 σ	95.5	96.7	94	90
2.5 σ	98.7	97.8	100	90
3.0 σ	99.7	98.5	100	100

TABLE X.—SHOWING HOW MUCH INFORMATION IS CONTAINED IN $\bar{X}$, σ AND k.

(Data from Special Study)

$\bar{X} = 0.1288''$, $\sigma = 0.00255''$, $k = -0.615$, $n = 492$

Cell midpoint	0.118	0.119	0.120	0.121	0.122	0.123	0.124	0.125	0.126	0.127	0.128
Observed frequency	1	0	3	0	6	11	13	16	34	44	67
Relative frequency, per cent	0.2	0	0.6	0	1.2	2.2	2.6	3.3	6.9	8.9	13.6
Computed relative frequency, per cent:											
Using $\bar{X}$, and σ, only (Normal Law)	0	0	0	0.2	0.5	1.2	2.7	5.2	8.6	12.1	14.8
Using $\bar{X}$, σ and k (Second Approximation)	0	0	0.1	0.4	1.0	1.8	3.0	4.5	6.9	10.0	13.5

Cell midpoint	0.129	0.130	0.131	0.132	0.133	0.134	0.135	0.136	0.137	0.138
Observed frequency	91	82	65	36	18	5	0	0	0	0
Relative frequency, per cent	18.6	16.7	13.2	7.3	3.7	1.0	0	0	0	0
Computed relative frequency, per cent:										
Using $\bar{X}$, and σ, only (Normal Law)	15.5	13.9	10.8	7.2	4.1	2.0	0.8	0.3	0.1	0
Using $\bar{X}$, σ and k (Second Approximation)	16.0	15.7	12.9	8.4	4.3	1.2	0.3	0	0	0

although it contributes nothing to the solution of the problem of estimating the percentage of the total number of observations lying within symmetric ranges about the average, $\bar{X}$, that is, the range $\bar{X} \pm t\sigma$. What it does do is to help in estimating observed percentages in ranges whose limits are *not* equally spaced above and below $\bar{X}$. In the opinion of the committee, however, the k for a single set of observations does not help very much unless n is greater than 250, and is rarely worth while presenting if n is less than 100. Table X gives an example of an attempt[1] to reproduce an original frequency distribution from the computed values of $\bar{X}$, σ, and k. The distribution is quite skew and it is apparent that the theoretical distribution based on $\bar{X}$, σ, and k approximates the observed distribution more closely than does that based on $\bar{X}$ and σ alone. The comparison is shown graphically in Fig. 15.

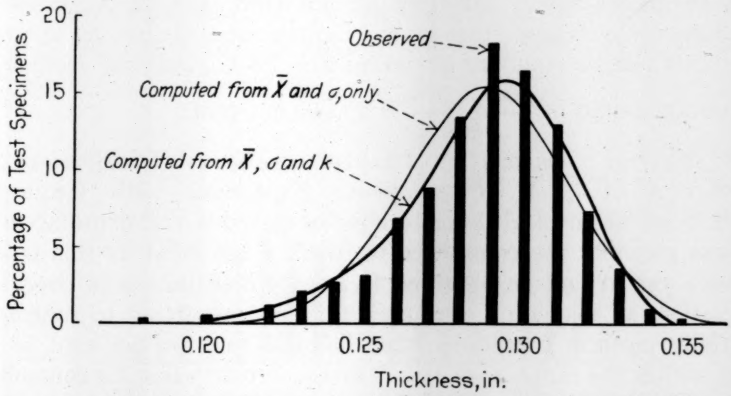

FIG. 15.—The Approximation Is Improved by Using k in Addition to $\bar{X}$ and σ.

Curves drawn through computed theoretical values of relative frequency.

34. *Use of Coefficient of Variation Instead of Standard Deviation.*—So far as quantity of information is concerned, the presentation of the coefficient of variation, v, together with the average, $\bar{X}$, is equivalent to presenting the standard deviation, σ, and the average, $\bar{X}$, since σ may be computed directly from the values of $v = \frac{100\sigma}{\bar{X}}$ and $\bar{X}$. In fact the coefficient of variation is nothing but σ expressed on a percentage basis. The coefficient of variation is sometimes useful in presentations whose purpose is to compare the *relative variability* of two or more distributions. If, for example, it were

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[1] For method of obtaining estimates of the observed cell frequencies using $\bar{X}$ and σ only (Normal Law) and $\bar{X}$, σ, and k (Second Approximation), see Shewhart, *op. cit.*, pp. 89–94.

desired to show for the data in the following table that the percentage variation is greater for *B* than for *A*, the coefficient of variation shows this fact, whereas the variation in pounds, expressed by the standard deviation, is greater for *A* than for *B*.

DATA	NUMBER OF OBSERVATIONS, n	AVERAGE STRENGTH, LB., $\bar{X}$	STANDARD DEVIATION, (VARIABILITY) LB., σ	COEFFICIENT OF VARIATION (RELATIVE VARIABILITY), PER CENT, v
A............	160	1100	225	20.4
B............	150	800	200	25.0

However, the presentation of the coefficient of variation may sometimes be misleading. To take an extreme case, if a series of measurements of temperature on the Centigrade scale had an average $\bar{X} = 0.01$ C. and a standard deviation $\sigma = 2.9$ C., then the coefficient of variation would be $\dfrac{100 \times 2.9}{0.01} = 29{,}000$ per cent.

35. *General Comment on Observed Frequency Distributions of a Series of A.S.T.M. Observations.*—Experience with frequency distributions for physical characteristics of materials and manufactured products prompts the committee to insert a comment at this point. We have yet to find an observed frequency distribution of over 100 observations of a quality characteristic and purporting to represent essentially uniform conditions, that has less than 96 per cent of its values within the range $\bar{X} \pm 3\sigma$. The theoretical value for controlled conditions is 99.7 per cent, as indicated in Fig. 14. Taking this as a starting point and considering the fact that in A.S.T.M. work the intention is, in general, to avoid throwing together into a single series data obtained under widely different conditions—different in an important sense in respect to the characteristic under inquiry—we believe that it is possible, in general, to use the methods indicated in Sections 32 and 33 for making rough estimates of the observed percentages of a frequency distribution, at least for making estimates (per Section 32) for symmetric ranges around the average, that is, $\bar{X} \pm t\sigma$. This belief depends, to be sure, upon our own experience with frequency distributions and upon the observation that such distributions tend, in general, to be unimodal—to have a single peak—as in Fig. 13.

Discriminate use of these methods is, of course, presumed. They could not be expected to give satisfactory results if the objective distribution were one like that shown in Fig. 16—a bimodal distribution representing two different sets of conditions. Here, however, the methods could be applied separately to each of the two rational subgroups of data.

36. *Summary.*

1. If a set of observations of a single variable is obtained under controlled conditions, much of the total information contained therein may be made available by presenting three functions—the average, $\bar{X}$, the standard deviation, σ, the skewness k—and the number, n, of observations. Of these, $\bar{X}$ and σ contribute most; k contributes something but, in the opinion of the committee, not very much unless n is greater than, say, 250.

2. The average, $\bar{X}$, and the standard deviation, σ, give some information even for data that are not obtained under controlled conditions. (Compare with Section 32.)

3. No single function, such as the average, of a set of observations is capable of giving much of the total information contained therein.

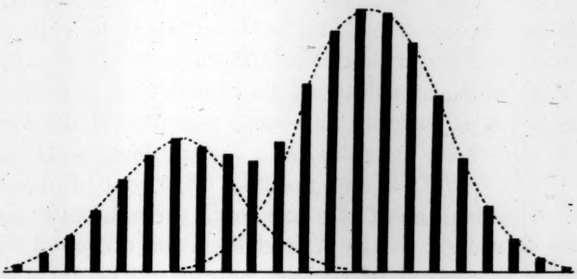

FIG. 16.—A Bimodal Distribution Arising from Two Different Systems of Causes.

4. Just what functions of the data should be presented in any instance depends on what uses are to be made of the data. This leads to a consideration of what constitutes the "essential information."

ESSENTIAL INFORMATION

37. *Introduction.*—Presentation of data presumes some intended use either by others or by the author as supporting evidence for his conclusions. The objective is to present that portion of the total information given by the original data that is believed to be essential for the intended use. *Essential information* will be described as follows:[1]

> "We take data to answer specific questions. One can usually say that a set of statistics [functions] contains the essential information given by the data when, through the use of these statistics, we can answer the questions in such a way that further analysis of the data will not modify our answers to any practical extent."

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[1] See Shewhart, *op. cit.*, p. 58.

The general introduction to the manual lists some of the objects of gathering A.S.T.M. data of the type under discussion—a set of observations of a single variable. Each such set constitutes an observed frequency distribution, and the information contained therein should be used efficiently in answering the questions that have been raised.

38. *What Functions of the Data Contain the Essential Information.*—The nature of the questions asked determines what part of the total information in the data constitutes the essential information for use in interpretation.

If we are interested in the percentages of the total number of observations that have values above (or below) several values on the scale of measurement, the essential information may be contained in a tabular grouped frequency distribution. But even here, if n is large and if the data represent controlled conditions, the essential information may be contained in the three functions—the average, $\bar{X}$, the standard deviation, σ, and the skewness k. If we are interested in the average and variability of the quality of a material, in the average quality of a material and some measure of the variability of averages for successive samples, in a comparison of the average or variability of the quality of one material with that of other materials, in the error of measurement of a test, etc., then the essential information may be contained in the $\bar{X}$ and σ of the observed distribution. If we are also interested in the percentage of the total quantity of product that does not conform with specified limits, then part of the essential information may be contained in the observed value of fraction defective, p.

If the conditions under which the data were obtained were not controlled, the maximum and minimum observations may contain information of value for detecting assignable causes of variation.

39. *Summary.*

1. What constitutes the *essential information* in any particular instance depends on the nature of the questions to be answered, and on the nature of the hypotheses which we are willing to make on the basis of available information pertaining thereto. Even when measurements of a quality characteristic are made under the same essential conditions, the objective quality is a *frequency distribution* which cannot be adequately described by any single numerical value.

2. Given a series of observations of a single variable arising from the same essential conditions, it is the opinion of the committee that the average, $\bar{X}$, the standard deviation, σ, and the number,

TABLE XI.—INFORMATION OF VALUE MAY BE LOST IF ONLY THE AVERAGE IS PRESENTED.

Material	Tensile Strength, lb. per sq. in. Condition *a* Average, $\overline{X}$	Condition *b* Average, $\overline{X}$	Condition *c* Average, $\overline{X}$
A	51 430	47 200	49 010
B	59 060	57 380	60 700
C	75 710	74 920	80 460

TABLE XII.—COMPARISON OF SEVERAL METHODS OF PRESENTING INFORMATION CONTAINED IN DATA.

(Data of Table I (*a*))

Method	Number of Observations	Transverse Strength, lb. per sq. in.		Explanation of Measure of Dispersion	Ranking of Measures of Dispersion: From Standpoint of Available Knowledge of Distribution Function	From Standpoint of Efficiency
1	270	Average, $\overline{X}$ 1000	Standard deviation, σ 202	Section 20	First	First
2	270	Average, $\overline{X}$ 1000	Coefficient of variation, v 20.2 per cent	$100\frac{\sigma}{\overline{X}}$ Section 21		
3	270	Average, $\overline{X}$ 1000	Average deviation 153	Section 21	Second	Second
4	270	Average, $\overline{X}$ 1000	Maximum 2010 Minimum 270	....		Third
5	270	Average, $\overline{X}$ 1000	Range 1740	Maximum − Minimum, Section 21		
6	270	Average, $\overline{X}$ 1000	Maximum 2010	....	Third	Fourth
7	270	Average, $\overline{X}$ 1000	Minimum 270	....		
8	270	Average, $\overline{X}$ 1000	Maximum deviation 1010	Maximum − $\overline{X}$ (or minimum − $\overline{X}$, if this is greater algebraically)		
9	270	Average, $\overline{X}$ 1000	Maximum percentage deviation 101 per cent	$100\frac{\text{Maximum deviation}}{\overline{X}}$		

TABLE XIII.—PRESENTATION OF ESSENTIAL INFORMATION.

(Data of Table XI)

		Tensile Strength, lb. per sq. in.					
		Condition *a*		Condition *b*		Condition *c*	
Material	Number of Tests	Average, $\overline{X}$	Standard Deviation, σ	Average, $\overline{X}$	Standard Deviation, σ	Average, $\overline{X}$	Standard Deviation, σ
A	20	51 430	920	47 200	830	49 010	1070
B	18	59 060	1320	57 380	1 360	60 700	1480
C	27	75 710	1840	74 920	1 650	80 460	1910

n, of observations contain the essential information for a majority of the uses made of such data in A.S.T.M. work.

COMMENTS ON VARIOUS METHODS USED IN PRESENTING DATA

40. *Introduction.*—Presentation of the essential information contained in a set of observations of a single variable commonly consists in recording the average, some measure of dispersion and the number of observations. This section discusses several methods that have been used.

41. *Average Only.*—Sometimes the average alone is given—no record is made of the dispersion of the observed values nor of the number of observations taken. For example, Table XI gives the observed average tensile strength for several materials under several conditions. The objective quality in each instance is a frequency distribution, from which the set of observed values may be considered as a sample. Much information of value may be lost by presenting merely the average, particularly if the number of observations is not given.

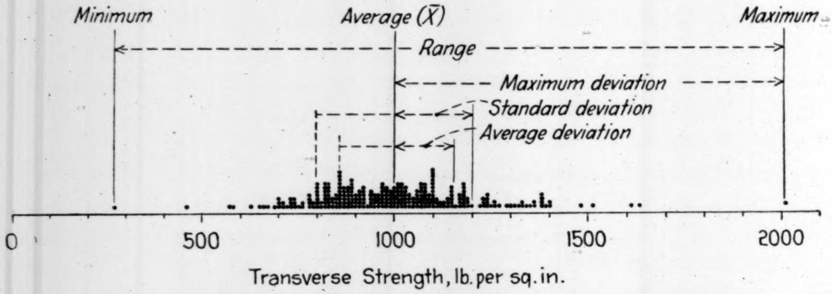

FIG. 17.—Showing Some of the Functions Listed in Table XII.
Data of Table I (*a*).

42. *Average and Some Measure of Dispersion.*—Presentation of the essential information generally requires a record of some measure of dispersion of the observed values. In Table XII are listed some of the methods that are used for presenting information contained in a set of observations, taking the data of Table I (*a*) as an example. The methods listed differ only in respect to the measures of dispersion, several of which are shown graphically in Fig. 17.

Evaluation of the comparative merits of these measures of dispersion involves a consideration of (1) the status of distribution theory, (2) efficiency, and (3) time required for computation. Table XII considers these factors broadly and gives a general notion of the kind of reasons why the standard deviation is usually the best measure of dispersion to use in presenting data. Table XIII illustrates how the essential information may be tabulated for several sets of observations, such as are obtained in investigations conducted for the purpose of comparing the quality of different materials.

Distribution Theory.—If samples of n observations each are drawn from a known universe, the observed values of any function, θ, such as the standard deviation, the average deviation, the range, the maximum, etc., will differ from sample to sample. For each function, θ, there is an objective distribution—for each value of n—whose average gives the expected value of θ and whose standard deviation gives a measure of how widely the observed values of θ may be expected to vary in repeated samples. Knowledge of the objective distribution functions is important in the interpretation and use of data. The available knowledge is, however, meager except for the standard deviation.[1]

Efficiency.—Roughly, the efficiency of a statistic, θ, is lower the larger the standard deviation of its objective distribution. Of the several measures of dispersion under discussion, none has as high an efficiency as the standard deviation. If, for a particular use to be made of a set of observations, we present a measure of dispersion that is only 80 per cent efficient as compared with the standard deviation, we in effect throw away 20 per cent of the data. As much could have been accomplished by taking only four-fifths as large a sample and using the more efficient standard deviation.[2]

Time Required for Computation.—The cost of getting data almost invariably justifies computing the standard deviation rather than getting more data and using one of the less efficient measures of dispersion. The use of the average deviation instead of the standard deviation, for example, usually arises from the argument that it takes less time to compute and is easier to understand. However, the experience of the committee covering a wide range of conditions indicates that the standard deviation can be computed as rapidly as the average deviation by the use of calculating machines, such as are ordinarily employed in analyzing the results of investigations that require any appreciable number of data. When only one or two computations are to be made, less time may be required for the average deviation, but it is believed that if tables of squares and square roots are used for computing the standard deviation, the difference in computation time, in favor of the average deviation, will be a small factor compared with the cost of the data effectually thrown away by using the average deviation. While the average deviation may perhaps be more easily understood than the standard (root-mean-square) deviation by those who are unfamiliar with statistical terms, it is confidently asserted that the significance of the standard deviation is soon appreciated with use.

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[1] See Shewhart, *op. cit.*, Chapter XIII.

It may be of interest to note that the *expected* value of any measure of dispersion that merely takes into account the maximum and/or the minimum observation (methods 4 to 9, inclusive, in Table XII) increases quite rapidly with the sample size, n. For example, the expected value of the range (maximum minus minimum) for samples of n observations each, drawn from a normal universe having a standard deviation, σ', varies with sample size in the following manner: The expected value of the range is 2.0 σ' for $n = 4$, 3.1 σ' for $n = 10$, 4.0 σ' for $n = 25$ and 6.1 σ' for $n = 500$. From this it is seen that in sampling from a normal universe, the spread between the maximum and the minimum observation may be expected to be about twice as great for a sample of 25 and three times as great for a sample of 500, as for a sample of 4. See L. H. C. Tippett, "On the Extreme Individuals and the Range of Samples Taken from a Normal Population," *Biometrika*, Vol. XVII, pp. 364–387, December, 1925.

For this reason the number of observations should be recorded in presentations which give the maximum and the minimum observations.

[2] A detailed discussion of efficiency is beyond the scope of this manual. See Shewhart, *op. cit.*, p. 172 and Chapter XIX.

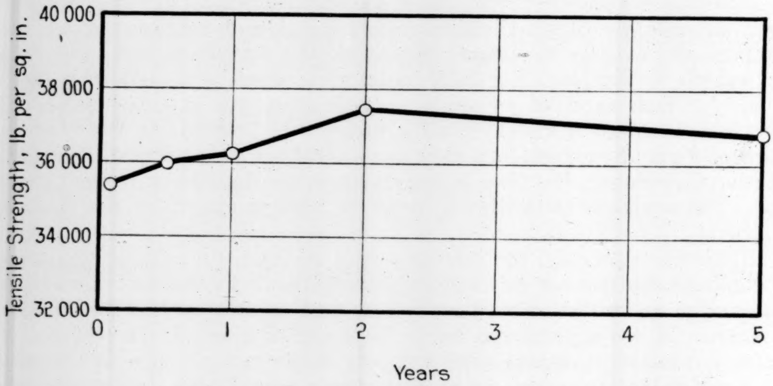

FIG. 18.—An Example of a Graph Showing an Observed Relationship.

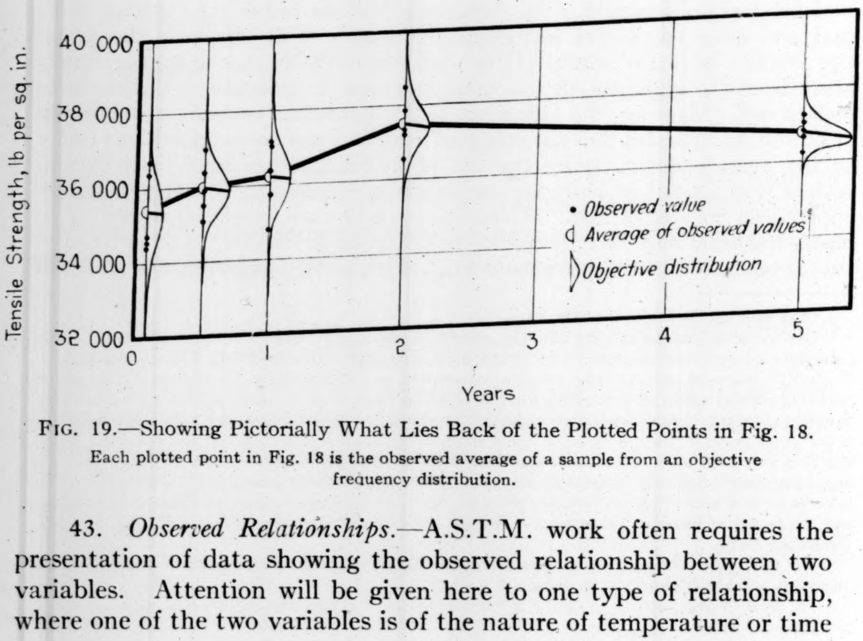

FIG. 19.—Showing Pictorially What Lies Back of the Plotted Points in Fig. 18.

Each plotted point in Fig. 18 is the observed average of a sample from an objective frequency distribution.

43. *Observed Relationships.*—A.S.T.M. work often requires the presentation of data showing the observed relationship between two variables. Attention will be given here to one type of relationship, where one of the two variables is of the nature of temperature or time

—one that is controlled at will by the investigator and considered for all practical purposes as capable of "exact" measurement, free from experimental errors.[1] Such relationships are commonly presented in the form of a chart consisting of a series of plotted points and straight lines connecting the points or a smooth curve which has been "fitted" to the points by some method or other. This section will consider merely the information associated with the plotted points.

Figure 18 gives an example of such an observed relationship.[2] At each successive stage of an investigation to determine the effect of aging on several alloys, five test specimens of each alloy were tested for tensile strength by each of several laboratories. The graph shows the results obtained by one laboratory for one of these alloys. Each of the plotted points is the average of five observed values of tensile strength and thus attempts to summarize an observed frequency distribution. Figure 19 has been drawn to show pictorially what is behind the scenes. The five observations made at each stage of the life history of the alloy constitute a sample from a universe of possible values of tensile strength—an objective frequency distribution whose spread is dependent on the inherent variability of the tensile strength of the alloy and on the error of testing. The dots represent the observed values of tensile strength and the bell-shaped curves, the objective distributions.

TABLE XIV.—SUMMARY OF ESSENTIAL INFORMATION FOR FIG. 18.

Time of Test	Number of Test Specimens	Tensile Strength, lb. per sq. in. Average, $\bar{X}$	Tensile Strength, lb. per sq. in. Standard Deviation, σ
Initial	5	35 400	950
6 months	5	35 980	668
1 year	5	36 220	869
2 years	5	37 460	655
5 years	5	36 800	319

In such instances, the essential information contained in the data may be made available by supplementing the graph by a tabulation of the averages, the standard deviations and the number of observations for the plotted points in the manner of Table XIV.

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[1] The problem of presenting information on the observed relationship between *two statistical variables*, such as hardness and tensile strength of an alloy sheet material, is more complex and will not be treated here. Discussions of this problem, together with methods of determining and using the correlation coefficient, lines of regression, etc., are given by Shewhart, *op. cit.*, Chapter IX. Illustrations and methods of using correlation in the analysis of data are given by Yule, *op. cit.*, Chapters X, XI, and XII. For an excellent technical discussion of correlation, see H. L. Rietz, "Mathematical Statistics," Chapter IV, Open Court Publishing Co., Chicago (1927).

[2] Data from records of shelf life tests on die-cast metals and alloys, Subcommittee XV of A.S.T.M. Committee B 2 on Non-Ferrous Metals and Alloys.

PRESENTATION OF RELEVANT INFORMATION

44. *Introduction.*—Empirical knowledge is not contained in the observed data alone, rather it arises from interpretation—an act of thought.[1] Interpretation consists in testing hypotheses based on prior knowledge. Data constitute but a part of the information used in interpretation—the judgments that are made depend as well on other pertinent information, much of which may be of a qualitative rather than of a quantitative nature.

If the data are to furnish a rational basis of prediction and generalization, they must be obtained under controlled conditions and must be free from constant errors of measurement. Mere presentation does not alter the goodness or badness of data. The usefulness of good data may, however, be enhanced by the manner in which they are presented.

45. *Relevant Information.*—Presented data should be accompanied by available relevant information, particularly information on *precisely* the field within which the measurements are supposed to hold and the conditions under which they were made, and evidence that the data are good. Among the specific things that may be presented with A.S.T.M. data to assist others in interpreting them or to build up confidence in the interpretation made by an author are:

1. The kind, grade and character of material or product tested.
2. The mode and conditions of production, if this has a bearing on the feature under inquiry.
3. The method of selecting the sample;[2] steps taken to insure its randomness or representativeness.
4. The specific method of test (if an A.S.T.M. or other standard test, so state; together with any modifications of procedure).
5. The specific conditions of test, particularly the regulation of factors that are known to have an influence on the feature under inquiry.
6. The precautions or steps taken to eliminate systematic or constant errors of observation.
7. The difficulties encountered and eliminated during the investigation.
8. Information regarding parallel but independent paths of approach to the end results.

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[1] See C. I. Lewis, "Mind and the World Order," Charles Scribner's Sons, New York (1929); an important discussion on the significance of prior information and hypothesis in the interpretation of data. See also J. M. Keynes, "A Treatise on Probability," Macmillan and Co., Ltd., London and New York (1921); one of the best modern treatises on the philosophy of probable inference which is of basic importance in the interpretation of any and all data.

[2] The manner in which the sample is taken has an important bearing on the interpretability of data. This problem is discussed by H. F. Dodge in "Statistical Control in Sampling Inspection," presented at a round table discussion on Acquisition of Good Data, held at the 1932 annual meeting of the Society; published in *American Machinist*, October 26 and November 9, 1932.

9. Evidence that the data were obtained under controlled conditions; the results of statistical tests made to support belief in the constancy[1] of conditions, in respect to the physical tests made and/or the material tested.

Much of this information may be qualitative in character, some may even be vague, yet without it the interpretation of the data and the conclusions reached may be misleading or of little value to others.

46. *Evidence of Control.*—One of the fundamental requirements of good data is that they should be obtained under controlled conditions. The interpretation of the observed results of an investigation depends on whether or not there is justification for believing that the conditions were controlled.

If the data are numerous and statistical tests[1] for control are made, evidence of control may be presented by giving the results of these tests.[2] Such quantitative evidence greatly strengthens inductive arguments. In any case, it is important to indicate clearly just what precautions were taken to control the essential conditions. Without tangible evidence of this character, the reader's degree of rational belief in the results presented will depend on his faith in the ability of the investigator to eliminate all causes of lack of constancy.

CONCLUSIONS

47. *Recommendations*[3] *for Presentation of Data.*—Given a set of *n* observations of a single variable obtained under the same essential conditions:

1. Present as a minimum, the average, the standard deviation, and the number of observations.

2. If the number of observations is large and if it is desired to give information regarding the shape of the distribution, present also the value of the skewness *k*, or present a grouped frequency distribution.

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[1] Here, we mean constancy in the statistical sense, which encompasses the thought of stability of conditions from one time to another and from one place to another. This state of affairs is commonly referred to as "statistical control." Statistical criteria have been developed by means of which we may judge when controlled conditions exist. Their character and mode of application are given by Shewhart, *op. cit.*, Chapters XX, XXI, and XXII. See also E. S. Pearson, "A Survey of the Uses of Statistical Method in the Control and Standardization of the Quality of Manufactured Products," *Journal*, Royal Statistical Soc. (London), Vol. XCVI, Part I, pp. 21–60 (1933).

[2] Several examples are available in recent issues of the *Proceedings* of the American Society for Testing Materials. In a paper by R. F. Passano, "Controlled Data from an Immersion Test," Vol. 32, Part II, p. 468 (1932), values of $\overline{X}$ and σ are given for each of a series of repetitive tests made under like conditions, and control charts are presented to show that the criterion for control has been satisfied. See also M. F. Skinker, "Application of Control Analysis to the Quality of Varnished Cambric Tape," Vol. 32, Part II, p. 670 (1932).

[3] Bearing in mind that no rules can be laid down to which no exceptions can be found, the committee believes that if these recommendations are followed, the presentations will contain the essential information for a majority of the uses made of A.S.T.M. data.

3. If the data were not obtained under controlled conditions and it is desired to give information regarding the effect of assignable causes, present the values of the maximum and minimum observations in addition to the average, the standard deviation and the number of observations.

4. Always state the number of observations taken.

5. Present as much evidence as possible that the data were obtained under controlled conditions.

6. Present relevant information on precisely (*a*) the field within which the measurements are supposed to hold and (*b*) the conditions under which they were made.

NOMENCLATURE

48. *Symbols Used in the Manual:*

X: a variable magnitude in a series of observations; a variable quality characteristic

X_1, X_2, X_3, etc.: observed values of X

n: the number of observations

$\bar{X}$: the arithmetic mean; referred to as the *average* in the manual

x: used in Section 25 to designate deviation in cells from an arbitrary origin; customarily used in statistical work to designate the deviation of an observed value, X_i, from the average, $\bar{X}$, that is, $x = X_i - \bar{X}$

y: observed frequency (number of observations) in a single cell of a frequency distribution

p: relative frequency, the ratio of the number of observations in any stated interval to the total number of observations; fraction defective, the ratio of the number of observations falling outside specified limits to the total number of observations

σ: the standard deviation—the root-mean-square deviation about the average, $\bar{X}$

σ^2: the variance

k: the skewness k, a measure of skewness or lopsidedness of a distribution

v: the coefficient of variation, a measure of relative dispersion based on the standard deviation

$\bar{X}'$, σ', etc.: the prime (′) notation is used to signify the *true* or objective value as distinct from the *observed* value

Σ: a mathematical symbol meaning *the sum of;* $\sum_{i=1}^{n}$ means the sum of, for all values of i from $i = 1$ to $i = n$, inclusive

REPORT OF COMMITTEE E-4

ON

METALLOGRAPHY

Committee E-4 on Metallography has held two meetings during the year, one in Atlantic City, N. J., on June 23, 1932, and the other in New York City on March 8, 1933. The committee has also furthered its work and activities through correspondence, particularly with relation to the examination of steels.

The resignation of Mr. L. W. McKeehan as chairman of Subcommittee VI on X-ray Methods is announced with regret, as are also the resignations of Messrs. G. F. Comstock, H. H. Lester, F. Sillers, Jr., and H. M. Williams.

Mr. Robert F. Mehl of the Carnegie Institute of Technology has been appointed as chairman of Subcommittee VI on X-ray Methods.

ACTIVITIES OF SUBCOMMITTEES

Subcommittee I on Selection and Preparation of Samples (E. H. Dix, Jr., chairman).—Further progress is reported on the revision of the Standard Methods of Metallographic Testing of Iron and Steel (E 3 - 24) and Methods of Metallographic Testing of Non-Ferrous Metals and Alloys (E 5 - 27). Additional data have been secured, particularly with relation to lead and steel. Contact has been established with Subcommittee VI on Metallography, of Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys, which subcommittee is investigating the polishing and etching of the corrosion-resistant steels.

Subcommittee III on Thermal Analysis (Howard Scott, chairman).—It was voted at the meeting in New York City that Committee E-4 recommend for advancement to standard the Tentative Recommended Practice for Thermal Analysis of Steel (E 14 - 30 T).

Special Subcommittee on Grain Characteristics of Steel (C. J. Tobin, chairman).—The need of grain size determinations for S.A.E. and allied steels has been quite generally recognized. The work of this subcommittee was prompted both by the need of grain size charts and by the need of uniformity of such charts in the different laboratories. A proposed tentative grain size chart for classification of steels was submitted to letter ballot in Committee E-4 in August of last year. In line with several negative votes and criticisms that were received the subcommittee modified the chart and it was subsequently submitted to letter ballot in Committee E-4, in December, 1932. The proposed Tentative Standard Grain Size Chart for Classification of Steels was then presented to the Society through Committee E-10 on Standards, and was accepted for publication as tentative[1] on March 8, 1933, and assigned the A.S.T.M. Designation E 19 – 33 T. The chart and text are available in separate pamphlet form.

For a wider recognition of the grain size chart and because of the desirability of having it published in the 1933 Book of A.S.T.M. Standards, it appears advisable to recommend at this time that the chart be adopted as standard. The chart is the result of laboratory work extending over a period of ten years and the proposed standard has been in the hands of the special subcommittee for two years.

RECOMMENDATIONS AFFECTING STANDARDS

The committee recommends that the Tentative Recommended Practice for Thermal Analysis of Steel (E 14 – 30 T),[2] which has been tentative for the past three years without revision, be adopted as standard.

The committee also recommends that the Tentative Standard Grain Size Chart for Classification of Steels (E 19 – 33 T) be adopted as standard. The committee accordingly asks for the necessary nine-tenths vote at the annual meeting in order that this recommendation may be submitted to letter ballot of the Society for immediate adoption since the chart has been published in tentative form less than one year.

The recommendations appearing in this report have been submitted to letter ballot of the committee with the following results:

Items	Affirmative	Negative	Not Voting
ADVANCEMENT OF TENTATIVE STANDARDS TO STANDARD			
Tentative Recommended Practice for Thermal Analysis of Steel (E 14 – 30 T)..........	35	0	0
Tentative Grain Size Chart for Classification of Steels (E 19 – 33 T), immediate adoption	33	0	2

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[1] In submitting this tentative standard to Committee E-10 on Standards, the committee reported results of the letter ballot vote as follows: Of a total membership of 52, 42 members returned their ballots, of whom 40 voted affirmatively and 1 negatively.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 1259 (1930); also 1932 Book of A.S.T.M. Tentative Standards, p. 1107.

This report has been submitted to letter ballot of the committee which consists of 49 members; 35 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

C. H. DAVIS,
Chairman.

O. E. HARDER,
Secretary.

EDITORIAL NOTE

The Tentative Recommended Practice for Thermal Analysis of Steel and the Tentative Grain Size Chart for Classification of Steels were approved at the annual meeting by a unanimous vote and subsequently adopted as standard by letter ballot of the Society on September 1, 1933. The standards appear in the 1933 Book of A.S.T.M. Standards, Part I, pages 931 and 898, respectively.

REPORT OF COMMITTEE E-6
ON
PAPERS AND PUBLICATIONS

The activities of Committee E-6 comprise the supervision of all publication matters including the development of the technical program for the annual meeting and the review of papers prior to their acceptance.

Program for 1933 Annual Meeting:

Probably the most outstanding feature for the program of this meeting is the Symposium on Cast Iron. This is the third of a series planned by the American Foundrymen's Association and our Society for the purpose of providing the engineering profession with authoritative data on the properties of castings. The assembling of data for this symposium has been in charge of the following committee:

H. Bornstein, *chairman*
D. M. Avey
A. L. Boegehold
J. W. Bolton
F. B. Coyle
H. W. Gillett
F. P. Gilligan
A. E. Hageboeck
R. E. Kennedy
J. T. MacKenzie
R. S. MacPherran
Oliver Smalley
E. K. Smith
E. R. Young

The Papers and Publications Committee wishes to express its appreciation of the services rendered by this committee. The publication of the symposium is being undertaken jointly by the A.F.A. and the A.S.T.M.

Another contribution of outstanding importance is a report on the significance of tests relating to concrete and concrete aggregates. The Society's Committee C-9 on Concrete and Concrete Aggregates has been at work for several years in the assembling of a discussion of the various test procedures applied to these materials and the report appearing on the program for the present annual meeting is the culmination of these efforts.

In addition to these features the program contains reports from nearly all of the standing and research committees and from several sectional committees functioning under A.S.A. procedure with the A.S.T.M. as sponsor. The total number of reports on the program is 47.

The technical papers on the program, in addition to those already mentioned in connection with the symposiums, cover many of the materials fields in which the Society is engaged, including cement and concrete, mortars, brick, corrosion and fatigue of metals, iron and steel, and testing. The program also provides for a round-table discussion on spectrographic analysis and for discussion on collection and interpretation of data. The total number of papers is 32 making a total of 79 items on the program.

While it has not been possible to preprint everything for the meeting due partly to budget limitations and partly to the fact that some few reports and papers were received so late as not to leave adequate time for editing and publication, all but 20 reports and papers have been printed; this includes 7 informal or progress reports and one technical paper which it is not intended to publish.

As usual the preprints were distributed to the members in advance of the meeting in two installments and a third installment is being distributed during the week of the meeting. The following table gives statistical information on preprinting:

	REPORTS		PAPERS		TOTAL	
	NUMBER	PAGES	NUMBER	PAGES	NUMBER	PAGES
Preprinted	37	565	22	299	59	864
Not preprinted	10	154[a]	10	393	20	547
	47	719	32	692	79	1411

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[a] Includes approximately 139 pages of material temporarily omitted from preprinted reports.

Papers for New York Regional Meeting:

The technical program for the fourth Regional Meeting of the Society held in New York City on March 8, 1933, constituted a Symposium on Motor Lubricants sponsored by the Society's Committee D-2 on Petroleum Products and Lubricants in cooperation with the Metropolitan Section of the Society of Automotive Engineers. The titles and authors of the seven papers comprising the symposium are given below:

Carbon Deposits in Gasoline Engines—W. A. Gruse.
Present Concepts of the Relation of A.S.T.M. Pour Test to Service Requirements of Oils—J. L. McCloud.
Viscosity of Automobile Crankcase Oils as Related to Service Requirements—E. W. Upham.
Service Changes in Crankcase Lubricating Oils—M. A. Dietrich.
Oil Consumption in Motor Car Engines—W. H. Graves.
Factors in Engine Design Which Affect Oil Performance—A. L. Clayden.
Aircraft Engine Lubrication—Arthur Nutt.

Proposed A.S.T.M. Journal:

At the direction of the Executive Committee, Committee E-6 has made a thorough study of the possibility of publishing a journal of the Society in order to provide more frequent contacts with the membership. A subcommittee appointed to study this problem made a careful review of the Society's publication set-up as well as a study of the publications of a number of other technical and professional societies functioning in a manner similar to the A.S.T.M. As a result of this study it reached the conclusion that while it would not seem desirable to undertake the immediate publication of a technical monthly journal, the Executive Committee might well consider a gradual expansion of the *Bulletin* to a reasonable magazine size. By the elimination of certain types of material from the *Proceedings*, it should be possible to make funds otherwise appropriated for the *Proceedings* available for the expanded *Bulletin*.

The following were considered as types of material that would be appropriate for inclusion in an enlarged *Bulletin:*

1. Papers such as those in the Symposium on the Economic Significance of Specifications for Materials, Chicago, 1931. (Issued also as a separate pamphlet as well as in the *Proceedings*.)

2. Papers of promotional value relating to standards, research, etc.

3. Papers not altogether appropriate for *Proceedings* (*Proceedings* papers would necessarily be more carefully reviewed, with a tightening of requirements.)

4. "Informational" papers which now have no outlet in our scheme. Papers given at local meetings, etc.

5. Papers not of sufficient permanent value to be given at meetings.

6. Letters on various subjects and matters (of which the Society receives many). This would be a sort of "letters to the editor" section.

7. Presidential address.

8. Interim committee reports.

9. Progress reports of committees.

10. Proposed methods, chiefly of an empirical nature, suggested by individuals and companies.

11. Proposed specifications and methods, procedures, etc., published as information by committees, given in journal rather than as at present in committee reports.

The Executive Committee approved a gradual expansion of the *Bulletin* as funds become available.

Regular Publications:

The regular publication activities carried on during the year are referred to in the annual report of the Executive Committee based upon information supplied by the Papers and Publications Committee.

In addition, the Papers and Publications Committee published new tentative standards submitted by the standing committees between annual meetings and approved by Committee E-10. In the past year eight such standards were thus published, the titles being given in the report of Committee E-10 on Standards.[1] Of these, all but two appeared in the *Proceedings* and in the Book of Tentative Standards for 1932. These two, namely, the Method of Test for Knock Characteristics of Motor Fuels (D 357 – 33 T) and the Tentative Standard Grain Size Chart for Classification of Steels (E 19 – 33 T), were printed early in 1933 and published in separate pamphlet form.

Papers Presented at New York District Meeting:

The following papers were presented at a Symposium on Timber held on November 17, 1932, in New York City, under the auspices of Committee D-7.

The Viewpoint of the Railroads—J. V. Neubert.
The Viewpoint of the Architect—E. J. Russell.
The Viewpoint of the Manufacturer—F. P. Cartwright.
The Use of Wooden Piling, Especially for Foundations—J. F. Seiler.
Protection of Timber Against Deterioration—Hermann von Schrenk.

Papers Presented at Meeting of Committee D-13:

The following papers have been reported to the Papers Committee as having been presented at the April meeting of Committee D-13 held in New York City:

Modern Test Methods—O. A. Belger.
A Comparison of the Skein and Serigraph Methods of Testing Cotton Yarns—G. B. Haven.
Cotton Fiber Quality: What Do We Know About It?—R. R. Webb.

Plans for 1934 Regional Meeting:

Plans are now being developed for a Symposium on Corrosion to be held in connection with the Regional Meeting of the Society in March, 1934. This symposium is being sponsored jointly by Committee A-5 on Corrosion of Iron and Steel and Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys.

Plans for 1934 Annual Meeting:

Plans are already under way for the 1934 annual meeting. Committee B-7 on Light Metals and Alloys, Cast and Wrought, is preparing a compilation of data relating to light metals and alloys. Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys also has in mind the publication of data on various corrosion-resistant steels.

Respectfully submitted on behalf of the committee,

C. L. WARWICK,
Chairman.

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[1] See p. 503.

REPORT OF COMMITTEE E-8

ON

NOMENCLATURE AND DEFINITIONS

Since relatively few definitions have required final action on the part of Committee E-8, no meeting of the committee has been deemed justified during the year in view of present economic conditions, action on the definitions having been handled by correspondence. Several of the subcommittees have been very active, however, notably the Subcommittees on Definitions of the Terms Net and Gross Calorific Values and on the Definition of the Term Coke, both under the chairmanship of Mr. H. C. Porter. Final reports from both of these subcommittees are included in this report. A Subcommittee on Definitions of Terms Relating to Heat Transmission has been organized during the year and has been engaged in the review of a number of definitions in this field. The Subcommittees on Concrete, on Sand and Aggregate, and on Sieve and Screen are being reorganized under the chairmanship of Mr. Cloyd M. Chapman.

Mr. G. B. Waterhouse has been appointed a member of the Advisory Committee, and Committee E-8 is indeed fortunate in having the services of Mr. Waterhouse on the Editorial Committee as a successor to Mr. Hugh P. Tiemann.

Of the definitions now published as tentative, the group relating to creosote[1] is being recommended for adoption as standard at this annual meeting. These definitions cover the following terms: Creosote (Creosote Oil, Creosote Distillate), Creosote - Coal Tar Solution, Coal Tar, Gas-House Coal Tar, Coke-Oven Tar and Water-Gas Tar.[2] These definitions are under the jurisdiction of Committee D-7 on Timber and have been reviewed by a subcommittee of Committee E-8 under the chairmanship of Mr. K. G. Mackenzie. Modifications of the definitions have been suggested and have met with the approval of Committee D-7. When these definitions are adopted, some few changes in the present definitions for coal tar and water-gas tar,[2] appearing in the Standard Definitions of Terms Relating to Materials for Roads and Pavements (D 8 - 18) under the jurisdiction of Committee D-4 on Road and Paving Materials, will need to be made and have been brought to the attention of Committee D-4.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 1154 (1930; also 1932) Book of A.S.T.M. Tentative Standards, p. 724.

[2] The adoption of the definition for water-gas tar was deferred, pending its further consideration by Committee D-4 on Road and Paving Materials and D-7 on Timber.

In addition to these terms, revised definitions of the terms[1] heat treatment, annealing, normalizing and tempering (also termed drawing), and a new definition for nitriding are being recommended for adoption as standard by the Society's Committee A-4 on Heat Treatment of Iron and Steel. These definitions were formulated by a joint committee representing the Society of Automotive Engineers, the American Society for Steel Treating and the A.S.T.M. They have been reviewed as to form by Committee E-8.

Committee A-2 on Wrought Iron[2] is recommending for adoption as standard a revision of the definitions for the terms double-refined iron and muck bar. Modifications in these definitions have been suggested by Committee E-8.

There is an ever increasing interest in the development of definitions. Aside from the actions referred to above, new definitions are being submitted this year by Committee C-10 on Hollow Masonry Building Units[3] and Committee D-13 on Textile Materials,[4] the latter committee submitting a complete glossary of terms relating to textiles.

Glossary of Terms.—The publication of the annual Glossary of terms appearing in the standards and tentative standards of the Society was omitted this year as an economy measure. This glossary, however, has been in such demand that its publication will be continued at the earliest opportunity.

ACTIVITIES OF SUBCOMMITTEES

Subcommittee on Definitions of Net and Gross Calorific Values (H. C. Porter, chairman).—This subcommittee was appointed in March, 1931, consisting of the following personnel:

H. C. Dickinson, representing the U. S. Bureau of Standards
A. C. Fieldner, representing the U. S. Bureau of Mines
A. E. Flowers, representing Committee D-2 on Petroleum Products and Lubricants
H. C. Porter, representing Committee D-5 on Coal and Coke
W. M. Saunders, representing Committee A-3 on Cast Iron
W. J. Wohlenberg, representing the American Society of Mechanical Engineers

It was the understanding of the subcommittee that it was charged only with the drafting of definitions for these terms and not with making any recommendations, comments or explanations as to the use of these values in engineering practice. The committee has had considerable correspondence, largely through Mr. O. C. Merrill, chairman of the American Committee for the World Power Conference, with officials in England and Germany relative to the definitions of these terms that are in use in those countries. The committee recommends that the definitions as set forth below be approved for submission to the standing committees concerned for consideration on the part of those committees for publication as tentative definitions.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, pp. 98, 985 (1932); also 1932 Book of A.S.T.M. Tentative Standards, p. 1129.

[2] See p. 79.—ED.

[3] See p. 682.—ED.

[4] See p. 944.—ED.

Net Calorific Value.—In the case of solid and liquid fuels burned at constant pressure, a calculated lower value obtained from the gross calorific value (at constant volume) by applying a correction based on the water condensed per unit quantity in the determination of the gross value.

NOTE.—The correction is a deduction of 1020 B.t.u. per pound (or 567 calories per gram) of water condensed per unit quantity of fuel in the determination of gross value (including the original moisture of the fuel as used and the water formed by combustion).

In the case of gaseous fuel, owing to the fact that the gross value is usually determined under constant pressure, the deduction is then 1050 B.t.u. per pound (or 583 calories per gram) of water condensed per unit quantity of fuel.

Gross Calorific Value.—In the case of solid and liquid fuels, the heat produced per unit quantity by complete combustion at constant volume in an oxygen bomb calorimeter under certain specified conditions.

NOTE.—The conditions are an initial pressure of 20 to 40 atmospheres within the calorimeter, a final temperature between 68 and 95 F. (20 and 35 C.) and with products consisting of ash, liquid water, and gaseous sulfur dioxide, carbon dioxide and nitrogen.

In the case of gaseous fuels, the determination is usually made in a form of calorimeter differing from the oxygen bomb and under conditions of constant pressure, not under constant volume.

From the definition for net calorific value it will be noted that the committee does not feel that this value should be defined as in any sense the practically effective heat that can be obtained in the burning of a fuel industrially. It is rather to be defined essentially as the lower value, calculated from the laboratory-determined gross value, by use of a factor which deducts as nearly as possible the quantity of heat resulting from condensation of water. The German Standards Association has used for this factor 585 large calories per kilogram of water (equivalent to 1053 B.t.u. per pound). The present Standard Methods of Laboratory Sampling and Analysis of Coal and Coke (A.S.T.M. Designation: D 271 – 30) states[1] that the "net heat of combustion at 20 C." shall be obtained by deducting from the gross value 1040 B.t.u. per pound of water condensed in the calorimeter. It is recommended now that this factor be changed to 1020 B.t.u. per pound of water condensed, since, by careful study of the matter and conference with experts of the U. S. Bureau of Standards and professors of mechanical engineering at various universities, the committee has come to an agreement that this factor more closely represents the difference in internal energy between liquid water in a calorimeter under constant volume conditions and that of water vapor existing under conditions of constant pressure as in the ordinary processes of combustion.

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 689.

Since the gross calorific values of gases are not usually determined under constant volume conditions, it is felt necessary to affix notes to the definitions explaining that for gaseous fuel the factor for calculating the net calorific value is not the same as in the case of solid and liquid fuels.

The recommendations of the subcommittee are being referred to Committee D-5 on Coal and Coke and to Committee D-2 on Petroleum Products and Lubricants for their consideration.

Subcommittee on Definitions of the Term Coke (H. C. Porter, chairman).—A definition for coke was prepared by Committee D-5 and published as tentative by that committee in 1927.[1] It subsequently developed that this definition as phrased was not entirely acceptable to other standing committees of the Society and accordingly in 1931 a subcommittee, consisting of the following personnel was organized to harmonize the conflicting views:

W. M. Saunders, representing Committee A-3 on Cast Iron
J. B. Rather, representing Committee D-2 on Petroleum Products and Lubricants
Prevost Hubbard, representing Committee D-4 on Road and Paving Materials
H. C. Porter, representing Committee D-5 on Coal and Coke

A revision of the earlier definition was prepared and submitted to Committee D-2, Committee D-5 and to the members of the Advisory Committee of Committee E-8. Modifications were proposed and the subcommittee is now recommending for approval by Committee E-8, for submission to the interested standing committees, the following definition of coke:

Coke.—The infusible, cellular, coherent, solid material obtained from coal, pitch, petroleum, petroleum residues, and some other carbonaceous materials, as the residue of destructive distillation, this residue having a characteristic physical structure resulting from the decomposition and hardening of a fused or semiliquid mass.

NOTE.—In the present state of the art, specific varieties of coke other than those from coal are distinguished by prefixing a qualifying word to indicate their source, as "petroleum coke" and "pitch coke." A word may also be prefixed to indicate the process by which coke is manufactured, as for example, in the case of coke from coal "beehive coke" and "gas-house coke."

This report has been submitted to letter ballot of the committee, which consists of 46 members; 30 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

CLOYD M. CHAPMAN,
Chairman.

R. E. HESS,
Ex-Officio Secretary.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 27, Part I, p. 962 (1927).

REPORT OF COMMITTEE E-9

ON

RESEARCH

In this its ninth annual report the Committee on Research presents a brief summary of the status of some of the important research projects which are being carried on under the auspices of the Society. A more comprehensive review will appear later in the A.S.T.M. Bulletin.

Research Committee Activities:

The Research Committee on Effect of Tin and Arsenic on High-Speed Tool Steels, finding that further work had been made unnecessary by the development of methods of freeing tungsten from arsenic and tin, has requested that it be discharged and its request has been granted.

The Research Committee on Yield Point of Structural Steel has been obliged to defer its program of tests dealing with the effect of aging and other factors on the yield point of structural steel because of conditions at the steel mills. In the meantime, a questionnaire on the significance of the yield point of structural steel to the designing engineer has been circulated and the replies are being analyzed for consideration of the committee.

The Research Committee on Fatigue of Metals has continued its cooperation with *Metals and Alloys* in preparing abstracts of articles on fatigue of metals.

The Joint Committee on Effect of Phosphorus and Sulfur in Steel has completed tests to determine effect of added phosphorus on low-carbon steel of the quality used in manufacture of pipe, and has presented a summary of the data and a brief report to the American Petroleum Institute which has conducted extensive tests on pipe made from the same material. The committee has also completed a series of tests to determine the effect of sulfur on forging steel and is now engaged in a study of the data and the preparation of a report to the sponsor societies. An informal report of these two series of tests will be made at this annual meeting; it is not yet possible to say when the reports can be published.

The Joint Research Committee of the A.S.M.E.-A.S.T.M. on Effect of Temperature on the Properties of Metals is finishing up its experimental work at Battelle Memorial Institute on creep of nickel-chromium austenitic steels at high temperatures and its work at the University of Illinois on the fatigue strength of these steels at the same temperatures. The studies of the committee over recent years have led to the development of tentative methods for short-time and long-time (creep) tension tests at elevated temperatures, which are being recommended to the Society in the committee's report[1] at this annual meeting.

The Joint Committee on Correlation of Research in Mineral Aggregates, functioning under the auspices of the Highway Research Board, National Research Council, has been quite active. It has assembled much information on the nature of shale and its effect when present in aggregates used in concrete and on coatings of various sorts on aggregates and their effects. Abrasion, hardness and toughness tests are receiving attention, and the significance of flat or elongated particles in aggregates is being considered. The committee is in constant touch with researches throughout the country on accelerated durability tests for aggregates. The standardization of an accelerated test and correlation with service behavior is recognized as a pressing necessity, and the committee is seeking to encourage coordination in these researches by distributing research outlines to interested agencies. The committee presented a report of its activities at the meeting of the Highway Research Board on December 1, 1932.

New Research Projects by Standing Committees:

The following new projects were reported in the review of research activities published in the A.S.T.M. Bulletin for October, 1932:

(*a*) *On Properties of Materials.*—Corrosion of malleable iron, galvanizing embrittlement of malleable iron (Committee A-7); effect of temperature of cement on use (Committee C-1).

(*b*) *On Methods of Testing.*—Evaluating thermostatic metals (Committee B-4); shrinkage of clay refractories (Committee C-8); corrosion tests for lubricating oils, tests for gum in gasoline, vapor lock of motor fuels (Committee D-2); extraction of bituminous aggregates (Committee D-4); tests of bituminous emulsions, tests of bituminous joint compounds for sewer pipe (Committee D-8); agglutinating value of coal, friability of coal (Committee D-5); tests of rayon fabrics, tests of silk textiles (Committee D-13); impact tests (Committee E-1).

Committee B-7 on Light Metals and Alloys is making splendid progress in the collection and correlation of data on light alloys under four major headings: industrial requirements, properties of aluminum-base alloys, properties of magnesium-base alloys and methods of protection. It was not possible to complete this report for publication this year as planned and it is expected that the information will be available in 1934.

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[1] See p. 209.—ED.

Once again the committee notes that the vast amount of material now published in the technical press, in the Proceedings of technical societies, and by government and educational institution research bureaus makes the occasional summary of current knowledge in a particular field highly desirable. The attention of committees of this Society is called to this fact.

Miscellaneous Administrative Matters:

The term of F. E. Schmitt expired in June, 1932, and H. E. Smith was appointed to membership in his place.

The term of F. R. McMillan expires at the close of this annual meeting; the appointment of his successor will be made by the Executive Committee of the Society.

The principal of the A.S.T.M. Research Fund is $8179.35. The balance of income as of May 31, 1933, is $1032.32.

Respectfully submitted on behalf of the committee,

H. F. MOORE,
Chairman.

C. L. WARWICK,
Secretary.

REPORT OF COMMITTEE E-10
ON
STANDARDS

Committee E-10 on Standards is being called upon to an ever increasing extent to act upon new tentative standards and revisions of tentative standards in the interval between annual meetings. Standing committees have had frequent occasion to use this procedure, particularly in connection with new tentative standards or revisions that come up for consideration at meetings of the standing committees during the annual meeting of the Society. In fact, Committee E-10 has made it a practice to hold a meeting during the summer to pass upon recommendations of standing committees so that the new or revised tentative standards approved may appear in the current Book of Tentative Standards and in the current *Proceedings* in the same manner as those submitted at the annual meeting of the Society. Steps are being taken to extend the so-called "E-10 procedure" to apply to proposed revisions of existing standards. Revisions of the By-laws to take care of this expansion are presented this year in the report of the Executive Committee. Two meetings of the committee have been held during the year; one in Philadelphia, Pa., on August 11, 1932, and the other in New York City on March 7, 1933.

The activities of the committee are set forth in this report under the following heads: review of A.S.T.M. standardization activities, consideration of new and revised tentative standards, promotion and expansion of standardization activities, and relations with American Standards Association.

REVIEW OF A.S.T.M. STANDARDIZATION ACTIVITIES

A general summary of the new tentative standards submitted at the 1932 annual meeting, of tentative standards advanced to standard and of revisions in standards was included in the July issue of the A.S.T.M. Bulletin, together with a review of the standardization work of the various committees with statements concerning new standards in prospect. Much of the information, particularly in respect to standardization projects in development in committees, is furnished by the standing committees subsequent to the annual meeting and takes advantage of the fact that many committees plan their next year's work at committee meetings held during the annual meeting.

At the present writing it is possible to make only an approximate estimate in terms of new and revised standards of the volume of standardization work accomplished during the year and reported to the Society at this meeting. The reports of standing committees to be presented at the annual meeting include recommendations to the Society substantially as follows:

New tentative standards	35
Tentative revisions of existing standards	13
Revisions of tentative standards	21
Tentative standards recommended for advancement to standard	60
Revisions of existing standards recommended for adoption as standard	83
Standards and tentative standards withdrawn	27

There are at present 441 standards and 228 tentative standards of the Society making a total of 669, and if the above recommendations are approved this total will become 681.

CONSIDERATION OF NEW AND REVISED TENTATIVE STANDARDS

Committee E-10 on receiving recommendations from standing committees on the submission of new tentative standards or revisions of existing tentative standards reviews them principally to insure that a substantial consensus has been reached in the standing committee concerned. It requires that a complete vote be recorded, analyzed according to producers, consumers, and general interests. If there are any negative votes the names of those voting in the negative must be recorded together with the reasons for so voting. A report from the standing committee is required giving the usual information, setting forth the needs for having the standard and on what data the standard is based, that is, whether it is based on standards already in existence or on work carried out by the committee, etc.

Proposed new standards that were approved by Committee E-10 and published as tentative during the year are as follows:

Tentative Method of Test for Knock Characteristics of Motor Fuels (D 357 - 33 T), submitted by Committee D-2 on Petroleum Products and Lubricants

Tentative Methods of Testing Laminated Round Rods Used in Electrical Insulation (D 349 - 32 T), submitted by Committee D-9 on Electrical Insulating Materials

Tentative Methods of Testing Flexible Varnished Tubing Used for Electrical Insulation (D 350 - 32 T), submitted by Committee D-9 on Electrical Insulating Materials

Tentative Methods of Testing Pasted Mica Used in Electrical Insulation (D 352 – 32 T), submitted by Committee D-9 on Electrical Insulating Materials

Tentative Method of Sampling Natural Building Stone and Sample for Testing (D 355 –32 T), submitted by Committee D-18 on Natural Building Stones

Tentative Method of Tension Testing of Natural Building Stone (D 356 – 32 T), submitted by Committee D-18 on Natural Building Stones

Tentative Methods of Rockwell Hardness Testing of Metallic Materials (E 18 – 32 T), submitted by Committee E-1 on Methods of Testing

Tentative Standard Grain Size Chart for Classification of Steels (E 19 – 33 T), submitted by Committee E-4 on Metallography

Revisions of the following tentative standards were approved by Committee E-10 and the tentative standards issued in their revised form:

Tentative Specifications for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83 – 32 T), submitted by Committee A-1 on Steel

Tentative Specifications for Fire-Refined Copper Other than Lake (B 72 – 32 T), submitted by Committee B-2 on Non-Ferrous Metals and Alloys

Tentative Methods of Chemical Analysis of Metallic Materials for Electrical Heating (B 71 – 33 T), submitted by Committee B-4 on Electrical-Heating, Electrical-Resistance and Electric-Furnace Alloys

Tentative Specifications for Copper-Base Alloys in Ingot Form for Sand Castings (B 30 – 32 T), submitted by Committee B-5 on Copper and Copper Alloys, Cast and Wrought

Tentative Specifications for Sand Castings of the Alloy: Copper 80 per cent; Tin 10 per cent; Lead 10 per cent (B 74 – 32 T), submitted by Committee B-5 on Copper and Copper Alloys, Cast and Wrought

Tentative Specifications for Concrete Building Brick (C 55 – 33 T), submitted by Committee C-3 on Brick

Tentative Method of Test for Ductility of Bituminous Materials (D 113 – 32 T), submitted by Committee D-4 on Road and Paving Materials

Tentative Method of Test for Residue of Specified Penetration (D 243 – 32 T), submitted by Committee D-4 on Road and Paving Materials

Tentative Method of Testing Sheet and Tape Insulating Materials for Dielectric Strength (D 149 – 32 T), submitted by Committee D-9 on Electrical Insulating Materials

Tentative Methods of Testing Varnished Cloths and Varnished Cloth Tapes Used in Electrical Insulation (D 295 – 32 T), submitted by Committee D-9 on Electrical Insulating Materials

Tentative Methods of Testing Laminated Tubes Used in Electrical Insulation (D 348 – 32 T), submitted by Committee D-9 on Electrical Insulating Materials

Tentative Definitions of Terms Relating to Methods of Testing (E 6 – 32 T), submitted by Committee E-1 on Methods of Testing

Tentative Methods of Tension Testing of Metallic Materials (E 8 – 32 T), submitted by Committee E-1 on Methods of Testing

PROMOTION AND EXPANSION OF STANDARDIZATION ACTIVITIES

The committee still has before it for consideration and development a number of projects that have been suggested as representing fields in which work should be undertaken by the Society. Some of these have progressed to the stage where it seems desirable to organize a standing committee to deal with the projects in question, the industry being canvassed to learn the desirability of work being initiated, whereas others are still receiving only preliminary study:

Paper and Allied Products
Testing Foundry Sands
Heat Insulation
Glues and Other Types of Adhesives
Acoustical Materials
Soils
Phenolic Products (Other than Electrical Insulation)

Comments of members in respect to any of these proposals are solicited.

The committee has undertaken an extensive review of the materials field to determine what further subjects should be receiving the attention of the standing committees of the Society. It is appreciated that there is considerable demand for standard specifications for many materials for which no standards as yet exist. A number of these materials are no doubt now possible of standardization.

RELATIONS WITH AMERICAN STANDARDS ASSOCIATION

Standards Submitted Under Proprietary Sponsorship Procedure.—The proprietary sponsorship procedure for submitting standards to the American Standards Association is particularly appropriate for a large number of A.S.T.M. standards. A number of standing committees now have under consideration the submission of existing A.S.T.M. standards to the A.S.A. under this method. The following standards have been submitted during the past year:

Standard Specifications for Gypsum (C 22 – 25)
Standard Specifications for Calcined Gypsum (C 23 – 30)
Standard Specifications for Gypsum Plasters (C 28 – 30)
Standard Specifications for Gypsum Molding Plaster (C 59 – 30)
Standard Specifications for Gypsum Pottery Plaster (C 60 – 30)

Two standards submitted to the A.S.A. in 1932 under the proprietary procedure have since been approved:

Standard Specifications for Lake Copper Wire Bars, Cakes, Slabs, Billets, Ingots and Ingot Bars (B 4 – 27)

Standard Specifications for Electrolytic Copper Wire Bars, Cakes, Slabs, Billets, Ingots and Ingot Bars (B 5 – 27)

Standards Submitted Under Sectional Committee Procedure.—Reports received from the Sectional Committee on Portland Cement and the Sectional Committee on Petroleum Products and Lubricants submitting standards to the A.S.A. for approval have been transmitted to that association and the following standards have been approved during the year:

On the Recommendation of the Sectional Committee on Portland Cement:

Standard Methods of Sampling and Testing Portland Cement (C 77 - 32), American Standard

On the Recommendation of the Sectional Committee on Petroleum Products and Lubricants:

Standard Method of Test for Flash Point of Volatile Flammable Liquids (D 56 - 21), American Standard

Standard Method of Test for Cloud and Pour Points (D 97 - 30), American Standard

Standard Method of Test for Melting Point of Petrolatum (D 127 - 30), American Standard

Standard Methods of Testing Gas Oils (Gravity, Distillation, Sulfur, Carbon Residue, Pour Point, Viscosity, Water) (D 158 - 28), American Standard

Standard Method of Test for Carbon Residue of Petroleum Products (Conradson Carbon Residue) (D 189 - 30), American Standard

Standard Method of Test for Distillation of Natural Gasoline (D 216 - 32), American Standard

Standard Method of Test for the Determination of Autogenous Ignition Temperatures (D 286 - 30), American Standard

Tentative Method of Test for Precipitation Number of Lubricating Oils (D 91 - 30 T), American Tentative Standard

Tentative Definitions of Terms Relating to Petroleum (D 288 - 31 T), American Tentative Standard

Tentative Method of Test for the Determination of Expressible Oil and Moisture in Paraffin Waxes (D 308 - 29 T), American Tentative Standard

Tentative Method of Test for Dilution of Crankcase Oils (D 322 - 30 T), American Tentative Standard

Sectional Committee Personnel.—Two sectional committees have recently been organized under A.S.A. procedure in which the Society is interested: a Sectional Committee on Electrical Measuring Instruments on which the Society is represented by Mr. Gordon Thompson and a Sectional Committee on Specifications and Methods of Test for Safety Glass on which a representative is still to be appointed.

The Society has also been asked by the A.S.A. to assume sponsorship for the development of specifications for putty.

There is now before the Electrical Standards Committee, which is the advisory committee of the American Standards Association on electrical subjects, a proposal that a Sectional Committee on

Electrical Insulating Materials be organized under the Society's sponsorship. This sectional committee, on which the several standing committees of the Society interested in electrical insulating materials will be represented as well as the several national bodies interested in this subject, will not only serve to review A.S.T.M. specifications looking toward their submission to the A.S.A. but will also act as a coordinating and planning committee to pass upon projects that should be undertaken under A.S.T.M. procedure. In this connection the Society has accepted assignment to develop the subject of shellac, synthetic resins and other similar insulating materials which project has been assigned to Committee D-9 on Electrical Insulating Materials.

Respectfully submitted on behalf of the committee,

T. R. LAWSON,
Chairman.

C. L. WARWICK,
Ex-Officio Secretary.

A.S.T.M.
TENTATIVE STANDARDS

ISSUED OR REVISED, 1933

The term Tentative Standard is applied to a proposed Standard which is printed for one or more years with a view of eliciting criticism, of which the committee concerned will take due cognizance before recommending final action toward its adoption as standard.

Members of the Society and others are invited to direct written criticism of any of these Tentative Standards to the officer of the appropriate committee, whose name and address appear in the footnote to the title of each Tentative Standard.

TENTATIVE SPECIFICATIONS
FOR
STEEL FOR BRIDGES[1]

A.S.T.M. Designation: A 7 – 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

Issued, 1933.[2]

1. (*a*) *Steel Castings.*—The Standard Specifications for Carbon-Steel Castings (A.S.T.M. Designation: A 27) of the American Society for Testing Materials,[3] shall govern the purchase of steel castings for bridges. Unless otherwise specified, class B castings, medium grade shall be used.

(*b*) *Structural Rivet Steel.*—Unless otherwise specified, the Standard Specifications for Structural Rivet Steel (A.S.T.M. Designation: A 141) of the American Society for Testing Materials,[4] shall govern the purchase of rivets for use with steel purchased under these specifications.

(*c*) *Forgings.*—The Standard Specifications for Carbon-Steel and Alloy-Steel Forgings (A.S.T.M. Designation: A 18) of the American Society for Testing Materials,[5] may also be used for forgings.

Rolled Base Plates

2. Rolled base plates over 2 in. in thickness for bearing purposes shall be open-hearth or electric-furnace steel containing 0.20 to 0.35 per cent carbon. The chemical composition shall also conform to the requirements specified in Section 4. A sufficient discard shall be made from each ingot to secure sound plates. Physical tests shall not be required for this material.

MANUFACTURE

Process

3. The steel shall be made by either or both of the following processes: open-hearth or electric-furnace.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. H. P. Bigler, Secretary of Committee A-1 on Steel, Rail Steel Bar Assn., 33 N. La Salle St., Chicago, Ill.

These Tentative Specifications are in effect a tentative revision of, and will supersede when adopted as standard, the present Standard Specifications for Structural Steel for Bridges (A.S.T.M. Designation: A 7 – 33), 1933 Book of A.S.T.M. Standards, Part I, p. 1.

[2] Accepted for publication as tentative by Committee E-10 on Standards, October 30, 1933.

[3] 1933 Book of A.S.T.M. Standards, Part I, p. 229.

[4] *Ibid.*, p. 27.

[5] *Ibid.*, p. 199.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition

4. The steel shall conform to the following requirements as to chemical composition:

Phosphorus, max., per cent	Acid	0.06
	Basic	0.04
Sulfur, max., per cent		0.05
Copper, when copper steel is specified, min., per cent		0.20

Ladle Analyses

5. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus and sulfur; also copper when copper steel is specified. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative and the percentages of phosphorus and sulfur, and copper when copper steel is specified, shall conform to the requirements specified in Section 4.

Check Analyses

6. Analyses may be made by the purchaser from finished material representing each melt. The phosphorus and sulfur content thus determined shall not exceed that specified in Section 4 by more than 25 per cent.

PHYSICAL PROPERTIES AND TESTS

Tension Tests

7. (*a*) The material, except as specified in Section 2 and Paragraph (*d*) of this section, shall conform to the following requirements as to tensile properties:

	PLATES, SHAPES AND BARS	EYEBAR FLATS UNANNEALED
Tensile strength, lb. per sq. in.	60 000 to 72 000	67 000 to 82 000[a]
Yield point, min., lb. per sq. in.	0.5 tens. str.	0.5 tens. str.
but in no case less than	33 000	36 000
Elongation in 8 in., min., per cent	$\frac{1\,500\,000}{\text{Tens. str.}}$[b]	$\frac{1\,500\,000}{\text{Tens. str.}}$[b]
Elongation in 2 in., min., per cent	22[c]	20[c]

[a] See Paragraph (*b*).

[b] See Section 8.

[c] See Section 10 (*e*) and (*g*).

(*b*) When finished eyebars are subject to full-size tests, the physical properties required for specimen tests of the eyebar flats unannealed shall be determined by the manufacturer of the eyebars.

(*c*) When full-size tests are specified for finished, annealed eyebars they shall conform to the following requirements as to tensile properties:

Tensile strength, min., lb. per sq. in.	60 000
Yield point, min., lb. per sq. in.	33 000
Elongation in 18 ft., min., per cent	12

The elongation shall be measured in the body of the bar including the fracture. The fracture shall show a silky or finely granular structure throughout.

(*d*) Flat-rolled steel $\frac{3}{16}$ in. and under in thickness, shapes less than 1 sq. in. in cross section and bars, other than flats, less than $\frac{1}{2}$ in. in thickness or diameter need not be subjected to tension tests.

(*e*) The yield point shall be determined by the drop of the beam or halt in the gage of the testing machine.

Modifications in Elongation

8. (*a*) For material over $\frac{3}{4}$ in. in thickness or diameter, a deduction from the percentage of elongation in 8 in. specified in Section 7 (*a*) of 0.25 per cent shall be made for each increase of $\frac{1}{32}$ in. of the specified thickness or diameter above $\frac{3}{4}$ in. to a minimum of 18 per cent for plates, shapes and bars and a minimum of 14 per cent for eyebar flats unannealed.

(*b*) For material under $\frac{5}{16}$ in. in thickness or diameter, a deduction from the percentage of elongation in 8 in. specified in Section 7 (*a*) of 1.25 per cent shall be made for each decrease of $\frac{1}{32}$ in. of the specified thickness or diameter below $\frac{5}{16}$ in.

Bend Tests

9. Bend test specimens shall stand being bent cold through 180 deg. without cracking on the outside of the bent portion around a pin the diameter of which shall have the following relation to the thickness of the specimen:

	RATIO: $\frac{\text{PIN DIAMETER}}{\text{THICKNESS OF SPECIMEN}}$	
THICKNESS OF MATERIAL	PLATES, SHAPES AND BARS	EYEBAR FLATS UNANNEALED
Up to $\frac{3}{4}$ in., inclusive	$\frac{1}{2}$	$1\frac{1}{2}$
Over $\frac{3}{4}$ to 1 in., inclusive	1	$2\frac{1}{2}$
Over 1 to $1\frac{1}{2}$ in., inclusive	$1\frac{1}{2}$	3
Over $1\frac{1}{2}$ to 2 in., inclusive	$2\frac{1}{2}$	4
Over 2 in.	3	$4\frac{1}{2}$

Test Specimens

10. (*a*) Test specimens shall be prepared for testing from the material in its rolled or forged condition, except as specified in Paragraph (*b*).

(*b*) Test specimens for annealed material, except eyebars, shall be prepared from the material as annealed for use or from a short length of a full section from the same melt similarly treated.

(*c*) Test specimens shall be taken longitudinally and, except as specified in Paragraphs (*e*), (*f*) and (*g*), shall be of the full thickness or section of material as rolled.

(*d*) Test specimens for plates, shapes and flats may be machined to the form and dimensions shown in Fig. 1, or with both edges parallel.

(*e*) Tension test specimens for material over $1\frac{1}{2}$ in. in thickness or diameter, except pins and rollers, may be machined to a thickness or diameter of at least $\frac{3}{4}$ in. for a length of at least 9 in. or they may conform to the dimensions shown in Fig. 2.

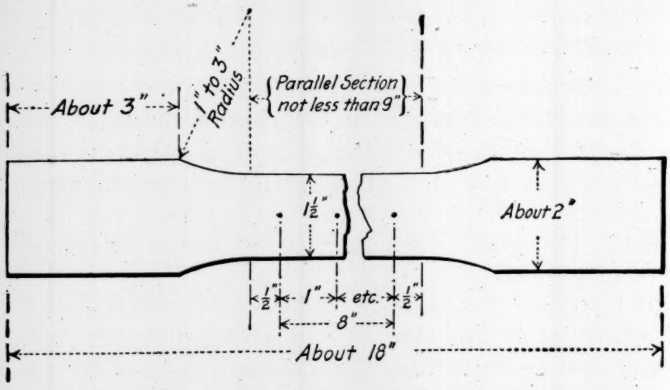


FIG. 1.—Standard 8-in. Gage Length Test Specimen.

(*f*) Bend test specimens for material over $1\frac{1}{2}$ in. in thickness or diameter, except pins and rollers, may be machined to a thickness or diameter of at least $\frac{3}{4}$ in. or to 1 by $\frac{1}{2}$ in. in section.

(*g*) Tension test specimens for pins and rollers shall conform to the dimensions shown in Fig. 2, and bend test specimens shall be 1 by $\frac{1}{2}$ in. in section.

(*h*) Test specimens for pins and rollers shall be taken so that the axis is 1 in. from the surface.

(*i*) The machined sides of rectangular bend test specimens may have the corners rounded to a radius not over $\frac{1}{16}$ in.

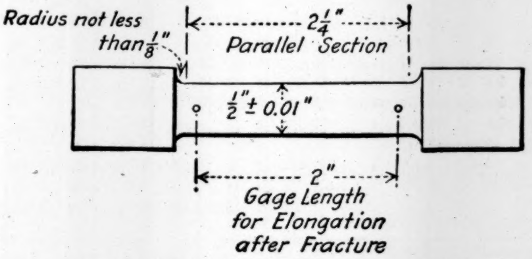
Number of Tests

11. (*a*) Two tension and two bend tests shall be made from each melt, unless the finished material from a melt is less than 30 tons when one tension and one bend test will be sufficient. If, however, material from one melt differs $\frac{3}{8}$ in. or more in thickness, one

tension and one bend test shall be made from both the thickest and thinnest material rolled regardless of the weight represented.

(*b*) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(*c*) If the percentage of elongation of any tension test specimen is less than that specified in Section 7 (*a*) and any part of the fracture is more than $\frac{3}{4}$ in. from the center of the gage length of a 2-in. specimen or is outside the middle third of the gage length of an 8-in. specimen, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.


Radius not less than 1/8"
2 1/4"
Parallel Section
1/2" ± 0.01"
2"
Gage Length for Elongation after Fracture

Note:- The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.

FIG. 2.—Standard 2-in. Gage Length Tension Test Specimen.

PERMISSIBLE VARIATIONS IN WEIGHT AND THICKNESS

Permissible Variations

12. (*a*) One cubic inch of rolled steel is assumed to weigh 0.2833 lb. The cross-sectional area or weight of each structural-size shape and of each universal mill plate up to and including 36 in. in width shall not vary more than 2.5 per cent from the theoretical or specified amounts. The thickness or weights of rectangular sheared mill plates and of rectangular universal mill plates over 36 in. in width shall conform to the requirements of Paragraphs (*b*), (*c*) and (*d*).

(*b*) *Plates, When Ordered to Weight per Square Foot.*—The weight of each lot[1] of plates in each shipment shall not vary from the weight ordered more than the amounts given in Table I.

(*c*) *Plates, When Ordered to Thickness.*—The thickness of each plate shall not vary more than 0.01 in. under that ordered.

The overweight in each lot[1] of plates in each shipment shall not exceed the amount given in Table II.

(*d*) *Plates Over 2 in. in Thickness.*—All plates over 2 in. in thickness shall conform to the permissible variations over ordered thickness given in Table III.

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[1] The term "lot" as applied to Table I means all the plates of each group width and group weight. As applied to Table II, it means all the plates of each group width and group thickness.

TABLE I.—PERMISSIBLE VARIATIONS OF RECTANGULAR PLATES ORDERED TO WEIGHT.

Ordered Weight, lb. per sq. ft.	Permissible Variations in Average Weights per Square Foot of Plates for Widths Given, Expressed in Percentages of Ordered Weights																		Ordered Weight, lb. per sq. ft.
	Under 48 in.		48 to 60 in., excl.		60 to 72 in., excl.		72 to 84 in., excl.		84 to 96 in., excl.		96 to 108 in., excl.		108 to 120 in., excl.		120 to 132 in., excl.		132 in. or over		
	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	
Under 5............	5	3	5.5	3	6	3	7	3	...	...	...	...	...	...	...	...	...	...	Under 5
5 to 7.5, excl....	4.5	3	5	3	5.5	3	6	3	...	...	...	...	...	...	...	...	...	...	5 to 7.5, excl.
7.5 " 10, "	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	...	...	...	...	7.5 " 10, "
10 " 12.5, "	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	9	3	10 " 12.5, "
12.5 " 15, "	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	12.5 " 15, "
15 " 17.5, "	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	15 " 17.5, "
17.5 " 20, "	2.5	2	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	17.5 " 20, "
20 " 25, "	2	2	2.5	2	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	20 " 25, "
25 " 30, "	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	4.5	3	5	3	25 " 30, "
30 " 40, "	2	2	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	4.5	3	30 " 40, "
40 " 81.6, incl....	2	2	2	2	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	40 " 81.6, incl.

NOTE.—The weight per square foot of individual plates shall not vary from the ordered weight by more than one and one-third the amount given in this table.

TABLE II.—PERMISSIBLE OVERWEIGHTS OF RECTANGULAR PLATES ORDERED TO THICKNESS.

Ordered Thickness, in.	Permissible Excess in Average Weights per Square Foot of Plates for Widths Given, Expressed in Percentages of Nominal Weights									Ordered Thickness, in.
	Under 48 in.	48 to 60 in., excl.	60 to 72 in., excl.	72 to 84 in., excl.	84 to 96 in., excl.	96 to 108in., excl.	108 to 120in., excl.	120 to 132in., excl.	132 in. or over	
Under $\frac{1}{8}$..................	9	10	12	14	....	....	....	....	....	Under $\frac{1}{8}$
$\frac{1}{8}$ to $\frac{3}{16}$, excl............	8	9	10	12	....	....	....	....	....	$\frac{1}{8}$ to $\frac{3}{16}$, excl.
$\frac{3}{16}$ " $\frac{1}{4}$, "	7	8	9	10	12	....	....	....	....	$\frac{3}{16}$ " $\frac{1}{4}$, "
$\frac{1}{4}$ " $\frac{5}{16}$, "	6	7	8	9	10	12	14	16	19	$\frac{1}{4}$ " $\frac{5}{16}$, "
$\frac{5}{16}$ " $\frac{3}{8}$, "	5	6	7	8	9	10	12	14	17	$\frac{5}{16}$ " $\frac{3}{8}$, "
$\frac{3}{8}$ " $\frac{7}{16}$, "	4.5	5	6	7	8	9	10	12	15	$\frac{3}{8}$ " $\frac{7}{16}$, "
$\frac{7}{16}$ " $\frac{1}{2}$, "	4	4.5	5	6	7	8	9	10	13	$\frac{7}{16}$ " $\frac{1}{2}$, "
$\frac{1}{2}$ " $\frac{5}{8}$, "	3.5	4	4.5	5	6	7	8	9	11	$\frac{1}{2}$ " $\frac{5}{8}$, "
$\frac{5}{8}$ " $\frac{3}{4}$, "	3	3.5	4	4.5	5	6	7	8	9	$\frac{5}{8}$ " $\frac{3}{4}$, "
$\frac{3}{4}$ " 1, "	2.5	3	3.5	4	4.5	5	6	7	8	$\frac{3}{4}$ " 1, "
1 " 2, incl............	2.5	2.5	3	3.5	4	4.5	5	6	7	1 " 2, incl.

NOTE.—The weight of individual plates ordered to thickness shall not exceed the nominal weight by more than one and one-third the amount given in this table.

FINISH

Finish

13. The finished material shall be free from injurious defects and shall have a workmanlike finish.

MARKING

Marking

14. The name or brand of the manufacturer and the melt number shall be legibly stamped or rolled on all finished material, except that lattice bars and other small sections shall, when loaded for shipment, be properly separated and marked for identification. The identification marks shall be legibly stamped on the end of each pin and roller. The melt number shall be legibly marked, by stamping, if practicable, on each test specimen.

TABLE III.—PERMISSIBLE VARIATIONS OVER ORDERED THICKNESS OF PLATES OVER 2 IN. IN THICKNESS.

NOTE.—Each plate shall not vary more than 0.01 in. under the ordered thickness.

Ordered Thickness, in.	Permissible Excess in Thickness, in.					
	Width, in.					
	Up to 36, excl.	36 to 60, excl.	60 to 84, excl.	84 to 120, excl.	120 to 132, excl.	132 to 144, excl.
Over 2 to 3, excl	0.062 ($\frac{1}{16}$)	0.094 ($\frac{3}{32}$)	0.109 ($\frac{7}{64}$)	0.125 ($\frac{1}{8}$)	0.125 ($\frac{1}{8}$)	0.141 ($\frac{9}{64}$)
3 " 4, "	0.078 ($\frac{5}{64}$)	0.094 ($\frac{3}{32}$)	0.109 ($\frac{7}{64}$)	0.125 ($\frac{1}{8}$)	0.125 ($\frac{1}{8}$)	0.141 ($\frac{9}{64}$)
4 " 6, "	0.094 ($\frac{3}{32}$)	0.125 ($\frac{1}{8}$)	0.141 ($\frac{9}{64}$)	0.141 ($\frac{9}{64}$)	0.156 ($\frac{5}{32}$)	0.172 ($\frac{11}{64}$)
6 " 8, "	0.109 ($\frac{7}{64}$)	0.125 ($\frac{1}{8}$)	0.156 ($\frac{5}{32}$)	0.156 ($\frac{5}{32}$)	0.172 ($\frac{11}{64}$)	....
8 " 10, "	....	0.172($\frac{11}{64}$)	0.187 ($\frac{3}{16}$)	0.187 ($\frac{3}{16}$)	....	....
10 " 12, "	....	0.187 ($\frac{3}{16}$)	0.234 ($\frac{15}{64}$)	0.234 ($\frac{15}{64}$)	....	....
12 " 15, "	....	0.219 ($\frac{7}{32}$)	0.250 ($\frac{1}{4}$)	....	....	....

INSPECTION AND REJECTION

Inspection

15. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection

16. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 6 shall be reported within five working days from the receipt of samples.

(*b*) Material which shows injurious defects subsequent to its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing

17. Samples tested in accordance with Section 6, which represent rejected material, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

TENTATIVE SPECIFICATIONS
FOR
STEEL FOR BUILDINGS[1]

A.S.T.M. Designation: A 9 – 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1933.[2]

1. *Structural Rivet Steel.*—Unless otherwise specified, the Standard Specifications for Structural Rivet Steel (A.S.T.M. Designation: A 141) of the American Society for Testing Materials,[3] shall govern the purchase of rivets for use with steel purchased under these specifications.

Rolled Base Plates

2. Rolled base plates over 2 in. in thickness for bearing purposes shall be open-hearth or electric-furnace steel containing 0.20 to 0.35 per cent carbon. The chemical composition shall also conform to the requirements specified in Section 4. A sufficient discard shall be made from each ingot to secure sound plates. Physical tests shall not be required for this material.

MANUFACTURE

Process

3. (*a*) The steel, except as specified in Paragraph (*b*), shall be made by one or more of the following processes: open-hearth, electric-furnace or acid-bessemer.

(*b*) Steel for plates and shapes over $\frac{7}{16}$ in. in thickness which are to be punched shall be made by either or both of the following processes: open-hearth or electric-furnace.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition

4. The steel shall conform to the following requirements as to chemical composition:

Phosphorus, max., per cent	Bessemer	0.10
	Open-hearth or electric-furnace	0.06
Copper, when copper steel is specified, min., per cent		0.20

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. H. P. Bigler, Secretary of Committee A-1 on Steel, Rail Steel Bar Assn., 33 N. La Salle St., Chicago, Ill.

These Tentative Specifications are in effect a tentative revision of, and will supersede when adopted as standard, the present Standard Specifications for Structural Steel for Buildings (A.S.T.M. Designation: A 9 – 33), 1933 Book of A.S.T.M. Standards, Part I, p. 8.

[2] Accepted for publication as tentative by Committee E-10 on Standards, October 30, 1933.

[3] 1933 Book of A.S.T.M. Standards, Part I, p. 27.

Ladle Analyses

5. (*a*) A carbon determination, and a copper determination when copper steel is specified shall be made of each melt of bessemer steel, and determinations for manganese, phosphorus and sulfur representing the average of the melts applied for each 8-hr. period.

(*b*) An analysis of each melt of open-hearth or electric-furnace steel shall be made to determine carbon, manganese, phosphorus and sulfur; also copper when copper steel is specified.

(*c*) The analyses prescribed in Paragraphs (*a*) and (*b*) shall be made by the manufacturer from test ingots taken during the pouring of each melt. The chemical composition thus determined shall be reported to the purchaser or his representative and the percentage of phosphorus, and also copper when copper steel is specified, shall conform to the requirements specified in Section 4.

Check Analyses

6. Analyses may be made by the purchaser from finished material representing each melt. The phosphorus content thus determined shall not exceed that specified in Section 4 by more than 25 per cent.

PHYSICAL PROPERTIES AND TESTS

Tension Tests

7. (*a*) The material, except as specified in Section 2 and Paragraph (*b*) of this section, shall conform to the following requirements as to tensile properties:

Tensile strength, lb. per sq. in.	60 000 to 72 000
Yield point, min., lb. per sq. in.	0.5 tens. str.
but in no case less than	33 000
Elongation in 8 in., min., per cent	$\frac{1\,400\,000}{\text{Tens. str.}}$ [a]
Elongation in 2 in., min., per cent	22 [b]

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[a] See Section 8.

[b] See Section 10 (*e*) and (*g*).

(*b*) Flat rolled steel $\frac{3}{16}$ in. and under in thickness, shapes less than 1 sq. in. in cross section and bars, other than flats, less than $\frac{1}{2}$ in. in thickness or diameter need not be subjected to tension tests.

(*c*) The yield point shall be determined by the drop of the beam or halt in the gage of the testing machine.

Modifications in Elongation

8. (*a*) For material over $\frac{3}{4}$ in. in thickness or diameter, a deduction from the percentage of elongation in 8 in. specified in Section 7 (*a*) of 0.25 per cent shall be made for each increase of $\frac{1}{32}$ in. of the

specified thickness or diameter above $\frac{3}{4}$ in., to a minimum of 16 per cent.

(*b*) For material under $\frac{5}{16}$ in. in thickness or diameter, a deduction from the percentage of elongation in 8 in. specified in Section 7 (*a*) of 1.25 per cent shall be made for each decrease of $\frac{1}{32}$ in. of the specified thickness or diameter below $\frac{5}{16}$ in.

Bend Tests

9. Bend test specimens shall stand being bent cold through 180 deg. without cracking on the outside of the bent portion, around a pin, the diameter of which shall have the following relation to the thickness of the specimen.

THICKNESS OF MATERIAL	RATIO: $\frac{\text{PIN DIAMETER}}{\text{THICKNESS OF SPECIMEN}}$
Up to $\frac{3}{4}$ in., inclusive	1
Over $\frac{3}{4}$ to 1 in., inclusive	$1\frac{1}{2}$
Over 1 to $1\frac{1}{2}$ in., inclusive	2
Over $1\frac{1}{2}$ to 2 in., inclusive	$2\frac{1}{2}$
Over 2 in.	3

Test Specimens

10. (*a*) Test specimens shall be prepared for testing from the material in its rolled or forged condition, except as specified in Paragraph (*b*).

(*b*) Test specimens for annealed material shall be prepared from the material as annealed for use, or from a short length of a full section from the same melt similarly treated.

(*c*) Test specimens shall be taken longitudinally and, except as specified in Paragraphs (*e*), (*f*) and (*g*), shall be of the full thickness or section of material as rolled.

(*d*) Test specimens for plates, shapes and flats may be machined to the form and dimensions shown in Fig. 1, or with both edges parallel.

(*e*) Tension test specimens for material over $1\frac{1}{2}$ in. in thickness or diameter, except pins and rollers, may be machined to a thickness or diameter of at least $\frac{3}{4}$ in. for a length of at least 9 in., or they may conform to the dimensions shown in Fig. 2.

(*f*) Bend test specimens for material over $1\frac{1}{2}$ in. in thickness or diameter, except pins and rollers, may be machined to a thickness or diameter of at least $\frac{3}{4}$ in. or to 1 by $\frac{1}{2}$ in. in section.

(*g*) Tension test specimens for pins and rollers shall conform to the dimensions shown in Fig. 2, and bend test specimens shall be 1 by $\frac{1}{2}$ in. in section.

(*h*) Test specimens for pins and rollers shall be taken so that the axis is 1 in. from the surface.

(*i*) The machined sides of rectangular bend test specimens may have the corners rounded to a radius not over $\frac{1}{16}$ in.

Number of Tests

11. (*a*) Two tension and two bend tests shall be made from each melt, unless the finished material from a melt is less than 30 tons when one tension and one bend test will be sufficient. If, however, material from one melt differs $\frac{3}{8}$ in. or more in thickness, one tension and one bend test shall be made from both the thickest and thinnest material rolled regardless of the weight represented.

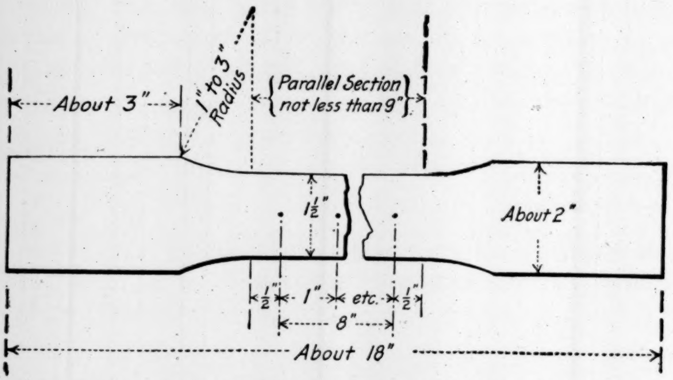
About 3"
1" to 3" Radius
Parallel Section not less than 9"
1½"
About 2"
½"
1"
etc.
½"
8"
About 18"

FIG. 1.—Standard 8-in. Gage Length Test Specimen.

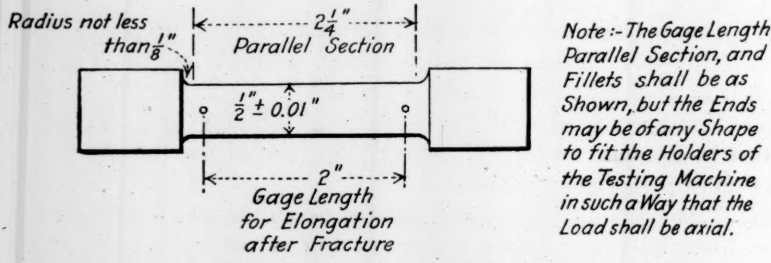
Radius not less than ⅛"
2¼"
Parallel Section
½" ± 0.01"
2"
Gage Length for Elongation after Fracture
Note:- The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.

FIG. 2.—Standard 2-in. Gage Length Tension Test Specimen.

(*b*) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(*c*) If the percentage of elongation of any tension test specimen is less than that specified in Section 7 (*a*) and any part of the fracture is more than $\frac{3}{4}$ in. from the center of the gage length of a 2-in. specimen

TABLE I.—PERMISSIBLE VARIATIONS OF RECTANGULAR PLATES ORDERED TO WEIGHT.

Ordered Weight, lb. per sq. ft.	Permissible Variations in Average Weights per Square Foot of Plates for Widths Given, Expressed in Percentages of Ordered Weights																		Ordered Weight, lb. per sq. ft.
	Under 48 in.		48 to 60 in., excl.		60 to 72 in., excl.		72 to 84 in., excl.		84 to 96 in., excl.		96 to 108 in., excl.		108 to 120 in., excl.		120 to 132 in., excl.		132 in. or over		
	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	
Under 5	5	3	5.5	3	6	3	7	3	...	...	...	...	...	...	...	...	...	...	Under 5
5 to 7.5, excl	4.5	3	5	3	5.5	3	6	3	...	...	...	...	...	...	...	...	...	...	5 to 7.5, excl.
7.5 " 10, "	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	...	...	...	...	7.5 " 10, "
10 " 12.5, "	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	9	3	10 " 12.5, "
12.5 " 15, "	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	12.5 " 15, "
15 " 17.5, "	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	15 " 17.5, "
17.5 " 20, "	2.5	2	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	17.5 " 20, "
20 " 25, "	2	2	2.5	2	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	20 " 25, "
25 " 30, "	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	4.5	3	5	3	25 " 30, "
30 " 40, "	2	2	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	4.5	3	30 " 40, "
40 " 81.6, incl	2	2	2	2	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	40 " 81.6, incl.

NOTE.—The weight per square foot of individual plates shall not vary from the ordered weight by more than one and one-third the amount given in this table.

TABLE II.—PERMISSIBLE OVERWEIGHTS OF RECTANGULAR PLATES ORDERED TO THICKNESS.

Ordered Thickness, in.	Permissible Excess in Average Weights per Square Foot of Plates for Widths Given, Expressed in Percentages of Nominal Weights									Ordered Thickness, in.
	Under 48 in.	48 to 60 in., excl.	60 to 72 in., excl.	72 to 84 in., excl.	84 to 96 in., excl.	96 to 108in., excl.	108 to 120in., excl.	120 to 132in., excl.	132 in. or over	
Under $\frac{1}{8}$	9	10	12	14	....	....	....	....	....	Under $\frac{1}{8}$
$\frac{1}{8}$ to $\frac{3}{16}$, excl	8	9	10	12	....	....	....	....	....	$\frac{1}{8}$ to $\frac{3}{16}$, excl.
$\frac{3}{16}$ " $\frac{1}{4}$, "	7	8	9	10	12	....	....	....	....	$\frac{3}{16}$ " $\frac{1}{4}$, "
$\frac{1}{4}$ " $\frac{5}{16}$, "	6	7	8	9	10	12	14	16	19	$\frac{1}{4}$ " $\frac{5}{16}$, "
$\frac{5}{16}$ " $\frac{3}{8}$, "	5	6	7	8	9	10	12	14	17	$\frac{5}{16}$ " $\frac{3}{8}$, "
$\frac{3}{8}$ " $\frac{7}{16}$, "	4.5	5	6	7	8	9	10	12	15	$\frac{3}{8}$ " $\frac{7}{16}$, "
$\frac{7}{16}$ " $\frac{1}{2}$, "	4	4.5	5	6	7	8	9	10	13	$\frac{7}{16}$ " $\frac{1}{2}$, "
$\frac{1}{2}$ " $\frac{5}{8}$, "	3.5	4	4.5	5	6	7	8	9	11	$\frac{1}{2}$ " $\frac{5}{8}$, "
$\frac{5}{8}$ " $\frac{3}{4}$, "	3	3.5	4	4.5	5	6	7	8	9	$\frac{5}{8}$ " $\frac{3}{4}$, "
$\frac{3}{4}$ " 1, "	2.5	3	3.5	4	4.5	5	6	7	8	$\frac{3}{4}$ " 1, "
1 " 2, incl	2.5	2.5	3	3.5	4	4.5	5	6	7	1 " 2, incl.

NOTE.—The weight of individual plates ordered to thickness shall not exceed the nominal weight by more than one and one-third the amount given in this table.

or is outside the middle third of the gage length of an 8-in. specimen, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

PERMISSIBLE VARIATIONS IN WEIGHT AND THICKNESS

Permissible Variations

12. (*a*) One cubic inch of rolled steel is assumed to weigh 0.2833 lb. The cross-sectional area or weight of each structural-size shape and of each universal mill plate up to and including 36 in. in width shall not vary more than 2.5 per cent from the theoretical or specified amounts. The thickness or weights of rectangular sheared mill plates and of rectangular universal mill plates over 36 in. in width shall conform to the requirements of Paragraphs (*b*), (*c*) and (*d*).

TABLE III.—PERMISSIBLE VARIATIONS OVER ORDERED THICKNESS OF PLATES OVER 2 IN. IN THICKNESS.

NOTE.—Each plate shall not vary more than 0.01 in. under the ordered thickness.

Ordered Thickness, in.	Permissible Excess in Thickness, in.					
	Width, in.					
	Up to 36, excl.	36 to 60, excl.	60 to 84, excl.	84 to 120, excl.	120 to 132, excl.	132 to 144, excl.
Over 2 to 3, excl	0.062 ($\frac{1}{16}$)	0.094 ($\frac{3}{32}$)	0.109 ($\frac{7}{64}$)	0.125 ($\frac{1}{8}$)	0.125 ($\frac{1}{8}$)	0.141 ($\frac{9}{64}$)
3 " 4, "	0.078 ($\frac{5}{64}$)	0.094 ($\frac{3}{32}$)	0.109 ($\frac{7}{64}$)	0.125 ($\frac{1}{8}$)	0.125 ($\frac{1}{8}$)	0.141 ($\frac{9}{64}$)
4 " 6, "	0.094 ($\frac{3}{32}$)	0.125 ($\frac{1}{8}$)	0.141 ($\frac{9}{64}$)	0.141 ($\frac{9}{64}$)	0.156 ($\frac{5}{32}$)	0.172 ($\frac{11}{64}$)
6 " 8, "	0.109 ($\frac{7}{64}$)	0.125 ($\frac{1}{8}$)	0.156 ($\frac{5}{32}$)	0.156 ($\frac{5}{32}$)	0.172 ($\frac{11}{64}$)	....
8 " 10, "	....	0.172 ($\frac{11}{64}$)	0.187 ($\frac{3}{16}$)	0.187 ($\frac{3}{16}$)	....	....
10 " 12. "	....	0.187 ($\frac{3}{16}$)	0.234 ($\frac{15}{64}$)	0.234 ($\frac{15}{64}$)	....	....
12 " 15, "	....	0.219 ($\frac{7}{32}$)	0.250 ($\frac{1}{4}$)	....	....	....

(*b*) *Plates, When Ordered to Weight per Square Foot.*—The weight of each lot[1] of plates in each shipment shall not vary from the weight ordered more than the amounts given in Table I.

(*c*) *Plates, When Ordered to Thickness.*—The thickness of each plate shall not vary more than 0.01 in. under that ordered.

The overweight in each lot[1] of plates in each shipment shall not exceed the amount given in Table II.

(*d*) *Plates Over 2 in. in Thickness.*—All plates over 2 in. in thickness shall conform to the permissible variations over ordered thickness given in Table III.

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[1] The term "lot" as applied to Table I means all the plates of each group width and group weight. As applied to Table II, it means all the plates of each group width and group thickness.

Finish

Finish

13. The finished material shall be free from injurious defects and shall have a workmanlike finish.

Marking

Marking

14. The name or brand of the manufacturer and the melt number shall be legibly stamped or rolled on all finished material, except that lattice bars and other small sections shall, when loaded for shipment, be properly separated and marked for identification. The identification marks shall be legibly stamped on the end of each pin and roller. The melt number shall be legibly marked, by stamping, if practicable, on each test specimen.

Inspection and Rejection

Inspection

15. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection

16. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 6 shall be reported within five working days from the receipt of samples.

(*b*) Material which shows injurious defects subsequent to its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing

17. Samples tested in accordance with Section 6, which represent rejected material, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

TENTATIVE SPECIFICATIONS
FOR
MILD STEEL PLATES[1]

A.S.T.M. Designation: A 10 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1933.[2]

Scope

1. These specifications cover a mild grade of steel suitable for general plate construction.

Structural Rivet Steel

2. Unless otherwise specified, the Standard Specifications for Structural Rivet Steel (A.S.T.M. Designation: A 141) of the American Society for Testing Materials,[3] shall govern the purchase of rivets for use with plates purchased under these specifications.

MANUFACTURE

Process

3. The steel shall be made by either or both of the following processes: open-hearth or electric-furnace.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition

4. The steel shall conform to the following requirements as to chemical composition:

Phosphorus, max., per cent	Acid	0.06
	Basic	0.04
Sulfur, max., per cent		0.05
Copper, when copper steel is specified, min., per cent		0.20

Ladle Analyses

5. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus and sulfur; also copper when copper steel is specified. This

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. H. P. Bigler, Secretary of Committee A-1 on Steel, Rail Steel Bar Assn., 33 N. La Salle St., Chicago, Ill.

[2] Accepted for publication as tentative by Committee E-10 on Standards, October 30, 1933.

[3] 1933 Book of A.S.T.M. Standards, Part I, p. 27.

analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative and the percentages of phosphorus and sulfur, and copper when copper steel is specified, shall conform to the requirements specified in Section 4.

Check Analyses

6. Analyses may be made by the purchaser from finished material representing each melt. The phosphorus and sulfur content thus determined shall not exceed that specified in Section 4 by more than 25 per cent.

PHYSICAL PROPERTIES AND TESTS

Tension Tests

7. (*a*) The material, except as specified in Paragraph (*b*), shall conform to the following requirements as to tensile properties:

Tensile strength, lb. per sq. in.	55 000 to 65 000
Yield point, min., lb. per sq. in.	0.5 tens. str.
but in no case less than	30 000
Elongation in 8 in., min., per cent	$\frac{1\ 500\ 000^{a}}{\text{Tens. str.}}$
Elongation in 2 in., min., per cent	24[b]

---

[a] See Section 8.

[b] See Section 10 (*e*).

(*b*) Flat rolled steel $\frac{3}{16}$ in. and under in thickness need not be subjected to tension tests.

(*c*) The yield point shall be determined by the drop of the beam or halt in the gage of the testing machine.

Modifications in Elongation

8. (*a*) For material over $\frac{3}{4}$ in. in thickness, a deduction from the percentage of elongation in 8 in. specified in Section 7 (*a*) of 0.25 per cent shall be made for each increase of $\frac{1}{32}$ in. of the specified thickness above $\frac{3}{4}$ in. to a minimum of 18 per cent.

(*b*) For material under $\frac{5}{16}$ in. in thickness, a deduction from the percentage of elongation in 8 in. specified in Section 7 (*a*) of 1.25 per cent shall be made for each decrease of $\frac{1}{32}$ in. of the specified thickness below $\frac{5}{16}$ in.

Bend Tests

9. Bend test specimens shall stand being bent cold through 180 deg. without cracking on the outside of the bent portion, around a

pin, the diameter of which shall have the following relation to the thickness of the specimen:

THICKNESS OF MATERIAL	RATIO: $\frac{\text{PIN DIAMETER}}{\text{THICKNESS OF SPECIMEN}}$
Up to ¾ in., inclusive	Flat on itself
Over ¾ to 1 in., inclusive	½
Over 1 to 1½ in., inclusive	1
Over 1½ to 2 in., inclusive	2
Over 2 in	2½

Test Specimens

10. (*a*) Test specimens shall be prepared for testing from the material in its rolled condition, except as specified in Paragraph (*b*).

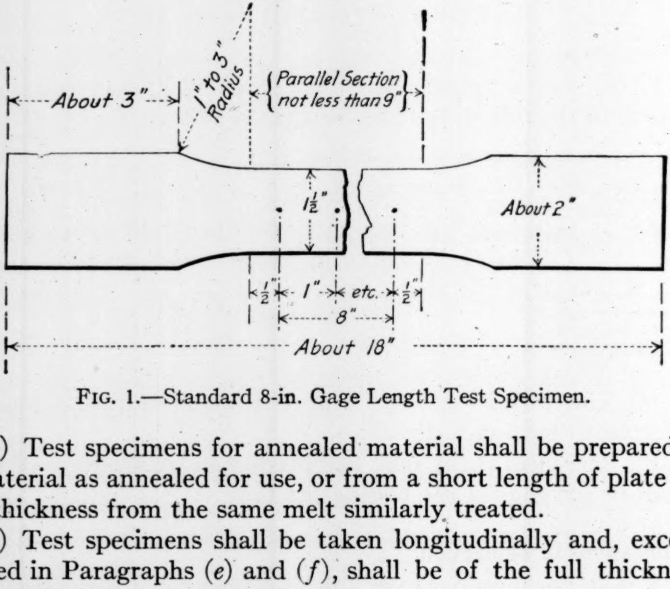


FIG. 1.—Standard 8-in. Gage Length Test Specimen.

(*b*) Test specimens for annealed material shall be prepared from the material as annealed for use, or from a short length of plate of the same thickness from the same melt similarly treated.

(*c*) Test specimens shall be taken longitudinally and, except as specified in Paragraphs (*e*) and (*f*), shall be of the full thickness of plate as rolled.

(*d*) Test specimens may be machined to the form and dimensions shown in Fig. 1, or with both edges parallel.

(*e*) Tension test specimens for material over 1½ in. in thickness may be machined to a thickness of at least ¾ in. for a length of at least 9 in., or they may conform to the dimensions shown in Fig. 2.

(*f*) Bend test specimens for material over 1½ in. in thickness may be machined to a thickness of at least ¾ in. or to 1 by ½ in. in section.

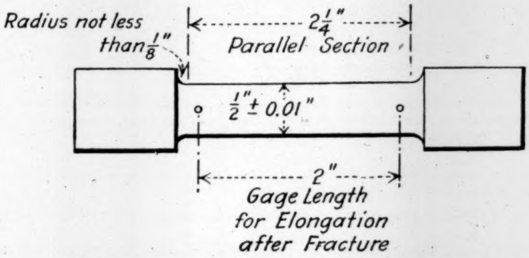
(*g*) The machined sides of rectangular bend test specimens may have the corners rounded to a radius not over $\frac{1}{16}$ in.

Number of Tests

11. (*a*) Two tension and two bend tests shall be made from each melt, unless the finished material from a melt is less than 30 tons when one tension and one bend test will be sufficient. If, however, material from one melt differs $\frac{3}{8}$ in. or more in thickness, one tension and one bend test shall be made from both the thickest and thinnest material rolled regardless of the weight represented.

(*b*) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(*c*) If the percentage of elongation of any tension test specimen is less than that specified in Section 7 (*a*) and any part of the fracture is more than $\frac{3}{4}$ in. from the center of the gage length of a 2-in. specimen or is outside the middle third of the gage length of an 8-in. specimen, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.


Radius not less than $\frac{1}{8}$"
$2\frac{1}{4}$"
Parallel Section
$\frac{1}{2}$" ± 0.01"
2"
Gage Length for Elongation after Fracture

Note:- The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.

FIG. 2.—Standard 2-in. Gage Length Tension Test Specimen.

PERMISSIBLE VARIATIONS IN WEIGHT AND THICKNESS

Permissible Variations

12. (*a*) One cubic inch of rolled steel is assumed to weigh 0.2833 lb. The cross-sectional area or weight of each universal mill plate up to and including 36 in. in width shall not vary more than 2.5 per cent from the theoretical or specified amounts. The thickness or weights of rectangular sheared mill plates and of rectangular universal mill plates over 36 in. in width shall conform to the requirements of Paragraphs (*b*), (*c*) and (*d*).

(*b*) *Plates, When Ordered to Weight per Square Foot.*—The weight of each lot[1] of plates in each shipment shall not vary from the weight ordered more than the amounts given in Table I.

(*c*) *Plates, When Ordered to Thickness.*—The thickness of each plate shall not vary more than 0.01 in. under that ordered.

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[1] The term "lot" as applied to Table I means all the plates of each group width and group weight. As applied to Table II, it means all the plates of each group width and group thickness.

TABLE I.—PERMISSIBLE VARIATIONS OF RECTANGULAR PLATES ORDERED TO WEIGHT.

Ordered Weight, lb. per sq. ft.	Permissible Variations in Average Weights per Square Foot of Plates for Widths Given, Expressed in Percentages of Ordered Weights																				Ordered Weight, lb. per sq. ft.
	Under 48 in.		48 to 60 in., excl.		60 to 72 in., excl.		72 to 84 in., excl.		84 to 96 in., excl.		96 to 108 in., excl.		108 to 120 in., excl.		120 to 132 in., excl.		132 in. or over				
	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under			
Under 5	5	3	5.5	3	6	3	7	3	...	...	...	...	...	...	...	...	...	...			Under 5
5 to 7.5, excl.	4.5	3	5	3	5.5	3	6	3	...	...	...	...	...	...	...	...	...	...			5 to 7.5, excl.
7.5 " 10, "	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	...	...	...	...			7.5 " 10, "
10 " 12.5, "	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	9	3			10 " 12.5, "
12.5 " 15, "	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3			12.5 " 15, "
15 " 17.5, "	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3			15 " 17.5, "
17.5 " 20, "	2.5	2	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3			17.5 " 20, "
20 " 25, "	2	2	2.5	2	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3			20 " 25, "
25 " 30, "	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	4.5	3	5	3			25 " 30, "
30 " 40, "	2	2	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	4.5	3			30 " 40, "
40 " 81.6, incl.	2	2	2	2	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3			40 " 81.6, incl.

NOTE.—The weight per square foot of individual plates shall not vary from the ordered weight by more than one and one-third the amount given in this table.

TABLE II.—PERMISSIBLE OVERWEIGHTS OF RECTANGULAR PLATES ORDERED TO THICKNESS.

Ordered Thickness, in.	Permissible Excess in Average Weights per Square Foot of Plates for Widths Given, Expressed in Percentages of Nominal Weights									Ordered Thickness, in.
	Under 48 in.	48 to 60 in., excl.	60 to 72 in., excl.	72 to 84 in., excl.	84 to 96 in., excl.	96 to 108in., excl.	108 to 120in., excl.	120 to 132in., excl.	132 in. or over	
Under $\frac{1}{8}$	9	10	12	14	....	....	....	....	....	Under $\frac{1}{8}$
$\frac{1}{8}$ to $\frac{3}{16}$, excl.	8	9	10	12	....	....	....	....	....	$\frac{1}{8}$ to $\frac{3}{16}$, excl.
$\frac{3}{16}$ " $\frac{1}{4}$, "	7	8	9	10	12	....	....	....	....	$\frac{3}{16}$ " $\frac{1}{4}$, "
$\frac{1}{4}$ " $\frac{5}{16}$, "	6	7	8	9	10	12	14	16	19	$\frac{1}{4}$ " $\frac{5}{16}$, "
$\frac{5}{16}$ " $\frac{3}{8}$, "	5	6	7	8	9	10	12	14	17	$\frac{5}{16}$ " $\frac{3}{8}$, "
$\frac{3}{8}$ " $\frac{7}{16}$, "	4.5	5	6	7	8	9	10	12	15	$\frac{3}{8}$ " $\frac{7}{16}$, "
$\frac{7}{16}$ " $\frac{1}{2}$, "	4	4.5	5	6	7	8	9	10	13	$\frac{7}{16}$ " $\frac{1}{2}$, "
$\frac{1}{2}$ " $\frac{5}{8}$, "	3.5	4	4.5	5	6	7	8	9	11	$\frac{1}{2}$ " $\frac{5}{8}$, "
$\frac{5}{8}$ " $\frac{3}{4}$, "	3	3.5	4	4.5	5	6	7	8	9	$\frac{5}{8}$ " $\frac{3}{4}$, "
$\frac{3}{4}$ " 1, "	2.5	3	3.5	4	4.5	5	6	7	8	$\frac{3}{4}$ " 1, "
1 " 2, incl.	2.5	2.5	3	3.5	4	4.5	5	6	7	1 " 2, incl.

NOTE.—The weight of individual plates ordered to thickness shall not exceed the nominal weight by more than one and one-third the amount given in this table.

The overweight in each lot[1] of plates in each shipment shall not exceed the amount given in Table II.

(*d*) *Plates Over 2 in. in Thickness.*—All plates over 2 in. in thickness shall conform to the permissible variations over ordered thickness given in Table III.

FINISH

13. The finished material shall be free from injurious defects and shall have a workmanlike finish.

MARKING

14. The name or brand of the manufacturer and the melt number shall be legibly stamped or rolled on all finished material. The melt number shall be legibly marked, by stamping, if practicable, on each test specimen.

TABLE III.—PERMISSIBLE VARIATIONS OVER ORDERED THICKNESS OF PLATES OVER 2 IN. IN THICKNESS.

NOTE.—Each plate shall not vary more than 0.01 in. under the ordered thickness.

Ordered Thickness, in.	Permissible Excess in Thickness, in.					
	Width, in.					
	Up to 36, excl.	36 to 60, excl.	60 to 84, excl.	84 to 120, excl.	120 to 132, excl.	132 to 144, excl.
Over 2 to 3, excl	0.062 ($\frac{1}{16}$)	0.094 ($\frac{3}{32}$)	0.109 ($\frac{7}{64}$)	0.125 ($\frac{1}{8}$)	0.125 ($\frac{1}{8}$)	0.141 ($\frac{9}{64}$)
3 " 4, "	0.078 ($\frac{5}{64}$)	0.094 ($\frac{3}{32}$)	0.109 ($\frac{7}{64}$)	0.125 ($\frac{1}{8}$)	0.125 ($\frac{1}{8}$)	0.141 ($\frac{9}{64}$)
4 " 6, "	0.094 ($\frac{3}{32}$)	0.125 ($\frac{1}{8}$)	0.141 ($\frac{9}{64}$)	0.141 ($\frac{9}{64}$)	0.156 ($\frac{5}{32}$)	0.172 ($\frac{11}{64}$)
6 " 8, "	0.109 ($\frac{7}{64}$)	0.125 ($\frac{1}{8}$)	0.156 ($\frac{5}{32}$)	0.156 ($\frac{5}{32}$)	0.172 ($\frac{11}{64}$)	....
8 " 10, "	....	0.172 ($\frac{11}{64}$)	0.187 ($\frac{3}{16}$)	0.187 ($\frac{3}{16}$)	....	....
10 " 12, "	....	0.187 ($\frac{3}{16}$)	0.234 ($\frac{15}{64}$)	0.234 ($\frac{15}{64}$)	....	....
12 " 15, "	....	0.219 ($\frac{7}{32}$)	0.250 ($\frac{1}{4}$)	....	....	....

INSPECTION AND REJECTION

Inspection

15. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to ship-

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[1] The term "lot" as applied to Table I means all the plates of each group width and group weight. As applied to Table II, it means all the plates of each group width and group thickness.

ment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection

16. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 6 shall be reported within five working days from the receipt of samples.

(*b*) Material which shows injurious defects subsequent to its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing

17. Samples tested in accordance with Section 6, which represent rejected material, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

TENTATIVE SPECIFICATIONS

FOR

HIGH TENSILE STRENGTH CARBON-STEEL PLATES FOR PRESSURE VESSELS[1]

(PLATES 2 IN. AND UNDER IN THICKNESS)

A.S.T.M. Designation: A 149 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1933.

Scope

1. These specifications cover high tensile strength carbon-steel plates 2 in. and under in thickness, of flange and firebox qualities, for boilers and other pressure vessels.

MANUFACTURE

Process

2. The steel shall be made by either or both of the following processes: open-hearth or electric-furnace.

Heat Treatment

3. (*a*) Plates over 1 in. in thickness shall be uniformly heat treated to produce grain refinement and to meet the physical properties specified.

(*b*) When the plates are heat treated at the steel mill they shall be tested in accordance with these specifications.

(*c*) Not all mills are equipped to heat treat plates. When the fabricator has the proper facilities and chooses to perform this work, he shall accept the plates from the manufacturer on the basis of tests made at the mill of pieces heat treated in the same manner as the plates. The fabricator shall specify on his order the heat treatment procedure he proposes to follow, in order that the manufacturer's tests may be comparable. Pieces for two complete sets of tests shall be furnished to the fabricator.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. H. P. Bigler, Secretary of Committee A-1 on Steel, Rail Steel Bar Assn., 33 N. La Salle St., Chicago, Ill.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition

4. The steel shall conform to the following maximum requirements as to chemical composition:

		FLANGE	FIREBOX
Carbon, per cent	for plates $\frac{3}{4}$ in. or under in thickness	0.32	0.32
	for plates over $\frac{3}{4}$ in. in thickness	0.35	0.35
Manganese, per cent		0.90	0.90
Phosphorus, per cent		0.04	0.035
Sulfur, per cent		0.05	0.04
Silicon, per cent		0.25	0.25

Ladle Analysis

5. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of the elements specified in Section 4. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 4.

Check Analysis

6. An analysis may be made by the purchaser from a broken tension test specimen representing each plate as rolled. The chemical composition thus determined shall conform to the requirements specified in Section 4.

PHYSICAL PROPERTIES AND TESTS

Tension Tests

7. (*a*) The material shall conform to the following requirements as to tensile properties:

Tensile strength, lb. per sq. in.	70 000 to 82 000
Yield point, min. lb. per sq. in.	0.5 tens. str.
Elongation in 8 in., min., per cent	$\frac{1\,600\,000}{\text{tens. str.}}$[a]

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[a] See Section 8.

(*b*) Tensile strength only need be determined on the test specimen taken longitudinally from the top of firebox plates, and it shall not exceed 84,000 lb. per sq. in.

(*c*) The yield point shall be determined by the drop of the beam or halt in the gage of the testing machine.

Modification in Elongation

8. For plates over $\frac{3}{4}$ in. in thickness, a deduction from the percentage of elongation specified in Section 7 (*a*) of 0.125 per cent shall be made for each increase of $\frac{1}{32}$ in. of the specified thickness above $\frac{3}{4}$ in. to a minimum of 19 per cent.

Bend Tests

9. The test specimen shall stand being bent cold through 180 deg. without cracking on the outside of the bent portion around a pin, the diameter of which shall have the following relation to the thickness of the specimen:

THICKNESS OF MATERIAL	RATIO: $\frac{\text{PIN DIAMETER}}{\text{THICKNESS OF SPECIMEN}}$
Up to 1 in., inclusive	2
Over 1 to 1½ in., inclusive	2½
Over 1½ to 2 in., inclusive	3

Homogeneity Tests

10. (*a*) The object of the homogeneity test, which is required for firebox steel only, is to open and render visible to the eye any seams due to failure to weld up or to interposed foreign matter, or any cavities due to gas bubbles in the ingot. The fractured surface of the specimen shall not show any single seam or cavity more than ¼ in. in length for plates ¾ in. and under in thickness, nor more than ⅜ in. in length for plates over ¾ in. to 2 in. in thickness, in any of the fractures obtained in accordance with Paragraph (*b*). One side of each fracture shall be examined and the lengths of the seams and cavities determined, a pocket lens being used if necessary.

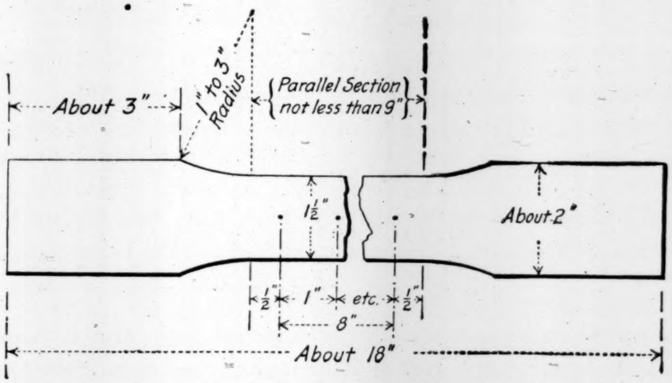

FIG. 1.—Standard 8-in. Gage Length Test Specimen.

(*b*) The test may be made on a broken tension test specimen. For plates ¾ in. and under in thickness the specimen shall be nicked or grooved transversely in three places, about $\frac{1}{16}$ in. deep. The first groove shall be 2 in. from the square end, and each succeeding groove on the opposite side about 2 in. from the preceding one. The specimen shall be broken at each groove in succession with a hammer or press, the bending being away from the groove. For plates over $\frac{3}{4}$ in. to 2 in., inclusive, in thickness, the specimen may be grooved about $\frac{1}{8}$ in. deep at one place on one side.

Test Specimens

11. (*a*) For heat-treated plates the pieces from which the test specimens are to be shaped shall be treated attached to the plates they represent.

(*b*) Tension test specimens for firebox material shall be taken from the top and bottom corners of the plate as rolled, parallel to its longitudinal axis, and for flange material from the bottom of the plate only. The bend test specimen shall be taken from the middle of the top of the plate as rolled, at right angles to its longitudinal axis.

TABLE I.—PERMISSIBLE OVERWEIGHTS OF PLATES ORDERED TO THICKNESS.

Ordered Thickness, in.	Permissible Excess in Average Weights per Square Foot of Plates for Widths Given, Expressed in Percentages of Nominal Weights									Ordered Thickness, in.
	Under 48 in.	48 to 60 in., excl.	60 to 72 in., excl.	72 to 84 in., excl.	84 to 96 in., excl.	96 to 108 in., excl.	108 to 120 in., excl.	120 to 132 in., excl.	132 in. or over	
Under $\frac{1}{8}$	9	10	12	14	..	..	..	..	..	Under $\frac{1}{8}$
$\frac{1}{8}$ to $\frac{3}{16}$, excl.	8	9	10	12	..	..	..	..	..	$\frac{1}{8}$ to $\frac{3}{16}$, excl.
$\frac{3}{16}$ to $\frac{1}{4}$, "	7	8	9	10	12	..	..	..	..	$\frac{3}{16}$ to $\frac{1}{4}$, "
$\frac{1}{4}$ to $\frac{5}{16}$, "	6	7	8	9	10	12	14	16	19	$\frac{1}{4}$ to $\frac{5}{16}$, "
$\frac{5}{16}$ to $\frac{3}{8}$, "	5	6	7	8	9	10	12	14	17	$\frac{5}{16}$ to $\frac{3}{8}$, "
$\frac{3}{8}$ to $\frac{7}{16}$, "	4.5	5	6	7	8	9	10	12	15	$\frac{3}{8}$ to $\frac{7}{16}$, "
$\frac{7}{16}$ to $\frac{1}{2}$, "	4	4.5	5	6	7	8	9	10	13	$\frac{7}{16}$ to $\frac{1}{2}$, "
$\frac{1}{2}$ to $\frac{5}{8}$, "	3.5	4	4.5	5	6	7	8	9	11	$\frac{1}{2}$ to $\frac{5}{8}$, "
$\frac{5}{8}$ to $\frac{3}{4}$, "	3	3.5	4	4.5	5	6	7	8	9	$\frac{5}{8}$ to $\frac{3}{4}$, "
$\frac{3}{4}$ to 1, "	2.5	3	3.5	4	4.5	5	6	7	8	$\frac{3}{4}$ to 1, "
1 or over	2.5	2.5	3	3.5	4	4.5	5	6	7	1 or over

(*c*) Tension and bend test specimens shall be of the full thickness of material as rolled, and shall be machined to the form and dimensions shown in Fig. 1; except that bend test specimens may be machined with both edges parallel. The sides of the bend test specimen may have the corners rounded to a radius of about $\frac{1}{16}$ in.

Number of Tests

12. (*a*) Two tension and one bend test shall be made from each firebox steel plate as rolled. One tension and one bend test shall be made from each flange steel plate as rolled.

(*b*) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(*c*) If the percentage of elongation of any tension test specimen is less than that specified in Section 7 (*a*) and any part of the fracture is outside the middle third of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

PERMISSIBLE VARIATIONS IN WEIGHT AND THICKNESS

Permissible Variations

13. The thickness of each plate shall not vary more than 0.01 in. under that ordered.

The overweight of each lot[1] in each shipment shall not exceed the amount given in Table I. One cubic inch of rolled steel is assumed to weigh 0.2833 lb.

FINISH

Finish

14. The finished material shall be free from injurious defects and shall have a workmanlike finish.

MARKING

Marking

15. (*a*) Except as specified in Paragraph (*e*), the name or brand of the manufacturer, the manufacturer's test identification number, class and lowest tensile strength specified shall be legibly stamped on each finished plate in two places not less than 12 in. from the edges and on each butt strap near the center line not less than 12 in. from each end. The manufacturer's test identification number shall be legibly stamped on each test specimen.

(*b*) When designated on the order, except as specified in Paragraph (*e*), plates shall be match-marked as defined in Paragraph (*c*) so that the test specimens representing them may be identified. When the plate rolled from a slab or ingot is cut into two or more smaller plates, each shall be match-marked so that they may all be identified with the test specimens representing them.

(*c*) Each match-mark shall consist of two over-lapping circles each not less than $1\frac{1}{2}$ in. in diameter, placed upon the shear lines, and made by separate impressions of a single-circle steel die.

(*d*) Match-marked coupons shall match with the sheets represented and only those which match properly shall be accepted.

(*e*) For plates under $\frac{1}{4}$ in. in thickness, the marking specified in Paragraphs (*a*) and (*b*) shall be legibly stenciled instead of stamped.

INSPECTION AND REJECTION

Inspection

16. The inspector representing the purchaser shall have free entry at all times while work on the contract of the purchaser is

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[1] The term "lot" applied to Table I means all of the plates of each group width and group thickness.

being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection

17. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 6, shall be reported within five working days from the receipt of samples.

(*b*) Material which shows injurious defects subsequent to its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing

18. Samples tested in accordance with Section 6 which represent rejected material, shall be preserved for two weeks from date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

TENTATIVE SPECIFICATIONS
FOR
HIGH TENSILE STRENGTH CARBON-STEEL PLATES FOR FUSION-WELDED PRESSURE VESSELS[1]

(PLATES OVER 2 IN. UP TO AND INCLUDING 4 IN. IN THICKNESS)

A.S.T.M. Designation: A 150 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1933.

Scope

1. These specifications cover two grades of high tensile strength carbon steel plates over 2 in. and up to and including 4 in. in thickness, of firebox quality, suitable for fusion-welded pressure vessels. The term grade is used to distinguish between different tensile ranges.

NOTE.—*Grade B Material.*—The A.S.M.E. Boiler Construction Code now requires that material for fusion welding shall not exceed 0.35 per cent carbon on check analysis. Since this maximum limitation on carbon restricts the thickness of plate that can be obtained to meet the specified physical requirements, the maximum thickness of plates purchased under these specifications will be a matter of agreement between the purchaser and the manufacturer.

MANUFACTURE

Process

2. The steel shall be made by either or both of the following processes: open-hearth or electric-furnace.

Heat Treatment

3. (*a*) All plates under these specifications shall be uniformly heat treated to produce grain refinement and to meet the physical properties specified.

(*b*) When the plates are heat treated at the steel mill they shall be tested in accordance with these specifications.

(*c*) Not all mills are equipped to heat treat plates. When the fabricator has the proper facilities and chooses to perform this work, he shall accept the plates from the manufacturer on the basis of tests made at the mill of pieces heat treated in the same manner as the plates. The fabricator shall specify on his order the heat treatment procedure he proposes to follow, in order that the manufacturer's tests may be comparable. Pieces for two complete sets of tests shall be furnished to the fabricator.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. H. P. Bigler, Secretary of Committee A-1 on Steel, Rail Steel Bar Assn., 33 N. La Salle St., Chicago, Ill.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition

4. The steel shall conform to the following requirements as to chemical composition:

Carbon, max., per cent	0.35
Manganese, per cent	0.50 to 0.90
Phosphorus, max., per cent: Acid	0.04
Phosphorus, max., per cent: Basic	0.035
Sulfur, max., per cent	0.04
Silicon, max., per cent	0.25

Ladle Analysis

5. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of the elements specified in Section 4. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 4.

Check Analysis

6. An analysis may be made by the purchaser from a broken tension test specimen representing each plate as rolled. The chemical composition thus determined shall conform to the requirements specified in Section 4.

PHYSICAL PROPERTIES AND TESTS

Tension Tests

7. (*a*) The material shall conform to the following requirements as to tensile properties:

	GRADE A	GRADE B
Tensile strength, lb. per sq. in	65 000 to 77 000	70 000 to 82 000
Yield point, min., lb. per sq. in	0.5 tens. str.	0.5 tens. str.
Elongation in 2 in., min., per cent	$\frac{1\ 750\ 000^{a}}{\text{tens. str.}}$	$\frac{1\ 750\ 000^{a}}{\text{tens. str.}}$

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[a] See Section 8.

(*b*) Tensile strength only need be determined on the tension test specimen taken longitudinally from the top of the plates, and it shall not exceed 79,000 lb. per sq. in. for Grade A, or 84,000 lb. per sq. in. for Grade B.

(*c*) The yield point shall be determined by the drop of the beam or halt in the gage of the testing machine.

Modifications in Elongation

8. For plates over 2½ in. in thickness, a deduction from the percentage of elongation specified in Section 7 (*a*) of 0.5 per cent shall be made for each increase of ½ in. of the specified thickness above 2½ in., to a minimum of 22 per cent for Grade A and 20 per cent for Grade B.

Bend Tests

9. The test specimen shall stand being bent cold through 180 deg. without cracking on the outside of the bent portion around a pin, the diameter of which shall have the following relation to the thickness of the specimen. When the test is made on a specimen reduced in thickness, the rolled surface shall be on the outer curve of the bend:

	RATIO: PIN DIAMETER / THICKNESS OF SPECIMEN	
THICKNESS OF MATERIAL	GRADE A	GRADE B
Up to 3 in., inclusive	2	2½
Over 3 to 4 in., inclusive	2½	3

Homogeneity Test

10. (*a*) The object of the homogeneity test is to open and render visible to the eye any seams due to failure to weld up or to interposed foreign matter, or any cavities due to gas bubbles in the ingot. The fractured surface of the specimen shall not show any single seam or cavity more than ⅜ in. in length for plates 2 to 4 in. in thickness. One side of the fracture shall be examined and the length of the seams and cavities determined, a pocket lens being used if necessary.

(*b*) The specimen for homogeneity test shall be taken adjacent, sidewise or lengthwise, to the top tension test specimen. The specimen shall be nicked or grooved transversely at one place on one side about ¼ in. deep for plates up to 2¼ in. in thickness, and broken with a hammer or press, the bending being away from the groove. For plates over 2¼ in. in thickness the specimen may be grooved at one place on both sides to leave a fracture which will include the horizontal axis of the plate and have a face at least 2 in. in depth.

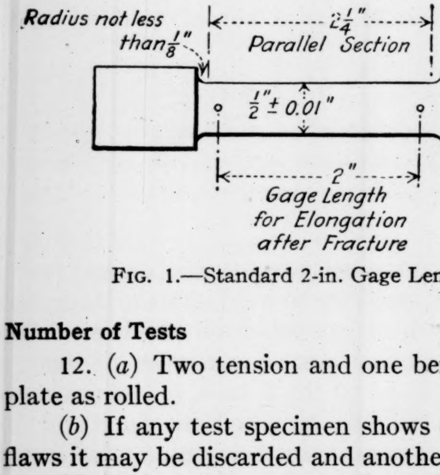
Test Specimens

11. (*a*) The tests shall represent the plates as heat treated for use. The pieces from which the test specimens are to be shaped shall be treated attached to the plates they represent.

(*b*) Tension test specimens shall be taken from the top and bottom corners of the plate as rolled, parallel to its longitudinal axis. The axis of the test specimen shall be located midway between the center and the top or bottom surface of the plate. The bend test specimen shall be taken from the middle of the top of the plate as rolled, at right angles to its longitudinal axis.

(*c*) Tension test specimens shall be machined to the form and dimensions shown in Fig. 1.

(*d*) The bend test specimen shall be at least 1½ in. in width, with both edges machined parallel. For material over 2 in. in thickness the specimen may be reduced to 2 in. in thickness, but it shall have one surface as rolled. The sides of the bend test specimen may have the corners rounded to a radius of about ⅛ in.


Radius not less than $\frac{1}{8}$"
$2\frac{1}{4}$"
Parallel Section
$\frac{1}{2}$" ± 0.01"
2"
Gage Length for Elongation after Fracture

Note:-The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.

FIG. 1.—Standard 2-in. Gage Length Tension Test Specimen.

Number of Tests

12. (*a*) Two tension and one bend test shall be made from each plate as rolled.

(*b*) If any test specimen shows defective machining or develops flaws it may be discarded and another specimen substituted.

(*c*) If the percentage of elongation of any tension test specimen is less than that specified in Section 7 (*a*) and any part of the fracture is more than ¾ in. from the center of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

PERMISSIBLE VARIATIONS IN THICKNESS

Permissible Variations

13. The plates shall be finished in accordance with the permissible variations in thickness for plates over 2 in. thick as adopted by the Association of American Steel Manufacturers, Technical Committees, 1933.

FINISH

Finish

14. The finished material shall be free from injurious defects and shall have a workmanlike finish.

MARKING

Marking

15. The name or brand of the manufacturer, the manufacturer's test identification number, class and lowest tensile strength for the grade specified in Section 7 (*a*) shall be legibly stamped on each finished plate in two places not less than 12 in. from the edges and on each butt strap near the center line not less than 12 in. from each end. The manufacturer's test identification number shall be legibly stamped on each test specimen.

INSPECTION AND REJECTION

Inspection

16. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection

17. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 6, shall be reported within five working days from the receipt of samples.

(*b*) Material which shows injurious defects subsequent to its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing

18. Samples tested in accordance with Section 6 which represent rejected material, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

TENTATIVE SPECIFICATIONS
FOR
CARBON-STEEL CASTINGS FOR INDUSTRIAL, RAILROAD, AND MARINE USES[1]

A.S.T.M. Designation: A 154 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1933.[2]

Scope

1. (*a*) These specifications cover carbon steel castings to be used for miscellaneous and jobbing purposes, for locomotive and car equipment, and for ship construction. Two classes and five grades of castings are covered: namely,

Class A.—Castings of one grade, designated as Special No. 1, for which no physical requirements are specified.

Class B.—Castings of four grades, designated as Regular, Special No. 2, Special No. 3 and Special No. 4, for each of which physical requirements are specified.

(*b*) Supplements M and R, relating respectively to marine and railroad castings, (Sections 19 to 25), shall be regarded as essential portions of these specifications, for the manufacture and testing of the materials mentioned.

MANUFACTURE

Process

2. The steel shall be made by one or more of the following processes: open-hearth, electric-furnace, converter, or crucible.

Heat Treatment

3. All castings of the Regular Grade, and Special Grades Nos. 3 and 4 shall receive a heat treatment to be selected by the manufacturer, adapted to the design, chemical composition, and intended

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. H. P. Bigler, Secretary of Committee A-1 on Steel, Rail Steel Bar Assn., 33 N. La Salle St., Chicago, Ill.

These specifications are in effect a tentative revision and proposed combination of the present Standard Specifications for Carbon-Steel Castings (A.S.T.M. Designation: A 27 - 24) and Standard Specifications for Carbon-Steel Castings for Railroads (A.S.T.M. Designation: A 87 - 27) (see 1933 Book of A.S.T.M. Standards, Part I, pp. 229, 234), and when adopted as standard are intended to supersede the specifications mentioned.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 16, 1933.

use of the castings (Note 1). A heat treatment selected by the manufacturer may be applied to castings of Special Grade No. 1, and shall be required when the carbon content exceeds 0.30 per cent. No heat treatment shall be required for castings of Special Grade No. 2.

NOTE 1.—According to current accepted definitions, the term "heat treatment" covers any method of intentionally and systematically applying heat to a metal after it has cooled following pouring. The term now is used without regard to whether heat is applied one or more times, and irrespective of the cooling procedure. The term "annealing" now is very broadly applied, and includes both "full annealing" (furnace cooling) and "normalizing" (air cooling).

4. (*a*) Heat treatment shall consist of one or more of the following heating and cooling procedures which, when applied properly, combine to develop grain refinement and other desirable qualities: (*a*) full annealing; or (*b*) normalizing; or (*c*) normalizing, followed by tempering or drawing; or (*d*) heating to the proper temperature and for the required time, followed by liquid quenching or liquid spraying or air blasting, with a subsequent tempering or drawing treatment, except when the purchaser consents to a different procedure (Note 2). No castings shall be liquid quenched, liquid sprayed, or air blasted without agreement between the manufacturer and the purchaser that the castings may be so treated.

(*b*) The procedure for full annealing shall consist of allowing the castings to cool after pouring, to a temperature below the critical range; reheating to the proper temperature and for the required time; and cooling slowly in the furnace (Note 3). The castings shall not be removed from the furnace until the pyrometer shows that the furnace has fallen to a temperature as low as 500 F.

(*c*) The procedure for normalizing shall consist of allowing the castings to cool after pouring, to a temperature below the critical range; reheating to the proper temperature and for the required time; and cooling in still air at room temperature (Note 3).

(*d*) The procedure for drawing or tempering shall consist of reheating castings previously full annealed, normalized, or liquid quenched, to some temperature below the critical range, but not lower than 400 F.; and subsequently cooling the castings by a method best suited to obtain the desired results.

(*e*) The procedure for accelerated cooling by liquid quenching, liquid spraying, or air blasting shall follow a gradual heating of the castings to a temperature above or below the critical range, and holding at that temperature for the proper time. After every accelerated cooling by quenching, spraying, or air blasting, the castings shall be tempered or drawn to relieve cooling stresses and/or strains, except when the purchaser consents to a different procedure. Castings that are liquid quenched, excepting those of very simple, light section-design, shall be removed from the quenching bath before they attain room temperature, and be placed in the furnace for any required tempering or drawing immediately following removal from the quenching bath (Note 4).

NOTE 2.—Accelerated cooling by liquid contact develops properties that are advantageous for many purposes, when the details of design and of shop practice are suitable for liquid quenching or liquid spraying. Among the beneficial results on steel castings, obtainable by quenching or spraying, is differential hardening, whereby some surfaces are made noticeably resistant to abrasion, while other portions of the castings may, if desired, retain a more ductile and economically machineable condition.

NOTE 3.—The proper time for holding castings introduced cold into the annealing furnace for the attainment of furnace temperature throughout the castings, is believed generally to be one hour for each inch of cross-section of the thickest members.

NOTE 4.—Usually the degree of hazard from liquid contact is estimated somewhat in proportion to the existing size and lack of uniformity in cross-section of members. Therefore, design and quenching practice details should be considered thoughtfully before authorizing liquid contact for accelerated cooling.

Temperature Control

5. Furnace temperatures for heat treating shall be controlled effectively by pyrometers.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition

6. Steel used for the castings shall conform to the following requirements as to chemical composition (Note 5):

	CLASS A	CLASS B
Carbon, max., per cent	0.45	....
Manganese, per cent	0.50 to 1.00	0.50 to 1.00
Silicon, per cent	0.20 to 0.75	0.20 to 0.75
Phosphorus, max., per cent	0.05	0.05
Sulfur, max., per cent	0.06	0.06

NOTE 5.—A maximum carbon content for Class A is specified mainly to identify the material as a grade steel suitable in the "as-cast" condition for parts not subjected to severe stresses that justify physical tests. The minimum percentages of manganese and silicon are specified to assure satisfactory deoxidation of the liquid steel. The maximum percentages of manganese and silicon are specified to aid in distinguishing between carbon and alloy cast steel. Generally, cast steel intended to contain more than 1.00 per cent manganese or 0.75 per cent silicon would be classified as an alloy steel, even if containing no unusual alloying element. The specified ranges of manganese and silicon are purposely made wide, to give proper latitude to the manufacturer for meeting physical requirements.

Ladle Analysis

7. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of the elements specified in Section 6. This analysis shall be made from drillings taken at least ¼ in. beneath the surface of a test ingot obtained during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative and shall conform to the requirements specified in Section 6.

Check Analysis

8. An analysis may be made by the purchaser from the broken tension test specimen or from a casting representing each melt. The chemical composition thus determined shall conform to the requirements specified in Section 6. Drillings for analysis shall be taken not less than ¼ in. beneath the surface, in such a manner as not to impair the usefulness of the casting.

PHYSICAL PROPERTIES AND TESTS

(Class B Castings Only)

Tension Tests

9. (*a*) Steel used for the castings shall conform to the following minimum requirements as to tensile properties[1] (Note 6):

	GRADE			
	REGULAR (NOTE 7)	SPECIAL No. 2 (NOTE 8)	SPECIAL No. 3 (NOTE 8)	SPECIAL No. 4 (NOTE 9)
Tensile strength, lb. per sq. in.	70 000	60 000	60 000	80 000
Yield point, lb. per sq. in.	38 000	30 000	30 000	43 000
Elongation in 2 in., per cent	24	22	26	17
Reduction of area, per cent	36	30	38	25

NOTE 6.—The minimum tensile properties herein specified are obtainable without liquid quenching or spraying. Higher combinations of tensile properties may be developed from liquid quenching and subsequent tempering or drawing.

NOTE 7.—The Regular Grade is the variety of carbon cast steel required for most miscellaneous structural purposes, for large tonnages of castings for railway rolling stock, and for many castings for ships. This grade is readily and economically machineable with ordinary machine tools.

NOTE 8.—Special Grades Nos. 2 and 3 are used mainly for the manufacture of certain large special castings for railway equipment. Steel of these grades is intended to have a low-carbon content, making the material very soft and machineable with great ease, either in the "as-cast" or in the annealed condition. It is believed, generally, that the low-carbon content of these grades gives them an important advantage over higher carbon steels, in economical and effective fusion fabrication with wrought parts of low-carbon steel.

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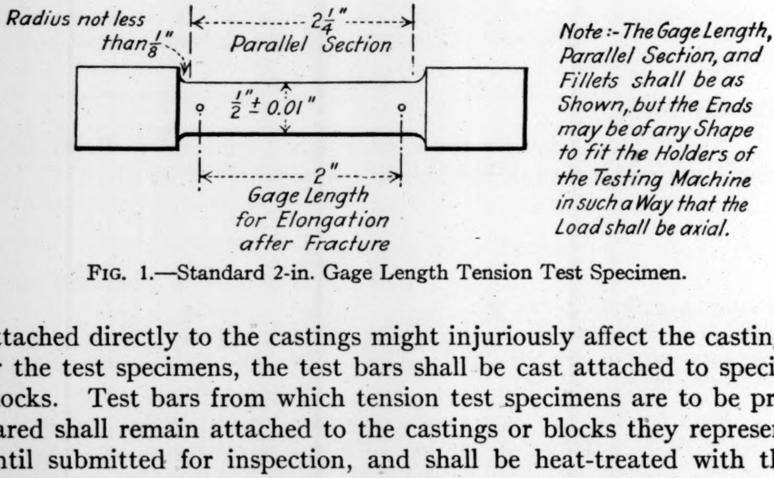
[1] Because it has come to the attention of Committee A-1 on Steel that the intent of tension test requirements in some specifications has at times been misinterpreted, the committee wishes to make it clear that it is not intended that a maximum limit shall be placed on any tensile property required in these specifications.

NOTE 9.—Special Grade No. 4 is used for purposes that call for higher strength and less required ductility than are typical of the Regular Grade. Usually, Special Grade No. 4 is machineable without appreciable difficulty with modern machine tools.

(*b*) The yield point shall be determined by the drop of the beam or halt in the gage of the testing machine, or by an extensometer, at a cross-head speed not to exceed $\frac{1}{8}$ in. per minute. The tensile strength shall be determined at a cross-head speed not exceeding $1\frac{1}{2}$ in. per minute.

Test Specimens

10. (*a*) Tension test specimens shall be prepared from test bars cast attached to castings, where practicable. If, in the judgment of the manufacturer, the design of the castings is such that test bars attached directly to the castings might injuriously affect the castings or the test specimens, the test bars shall be cast attached to special blocks. Test bars from which tension test specimens are to be prepared shall remain attached to the castings or blocks they represent until submitted for inspection, and shall be heat-treated with the castings, unless the purchaser authorizes separate treatment. Test bars shall be provided by the manufacturer without extra charge except as may be otherwise agreed to, in sufficient number to furnish specimens for all tests required in these specifications.


Radius not less than $\frac{1}{8}$"
$2\frac{1}{4}$"
Parallel Section
$\frac{1}{2}$" ± 0.01"
2"
Gage Length for Elongation after Fracture

Note:- The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.

FIG. 1.—Standard 2-in. Gage Length Tension Test Specimen.

(*b*) If mutually satisfactory to the manufacturer and the purchaser's inspector, tension test specimens may be cut from castings instead of from test bars.

(*c*) Tension test specimens shall be machined, and shall conform to the dimensions shown in Fig. 1. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial.

Number of Tests

11. (*a*) One tension test shall be made from each melt in each heat treatment charge.

(*b*) If any test specimen shows defective machining or develops flaws, it may be discarded, in which case another specimen from the same lot[1] shall be substituted.

(*c*) After 15 consecutive melts containing Class B castings (with exceptions as specified in Supplements M and R, Sections 19 to 25) have been accepted under these specifications for one or more orders, the manufacturer may assemble in groups of five melts not exceeding 40 tons each the castings subsequently made. The purchaser shall accept all castings in every such group, if the test specimen representing the group conforms to the chemical and physical requirements specified in Sections 6 and 9. If this test fails, a rehearing shall be granted on the melt represented by the failed specimen and the four other melts of the group shall be tested individually in accordance with Paragraphs (*a*) and (*b*) of this section.

Retests

12. (*a*) If the percentage of elongation of any tension test specimen is less than that specified in Section 9 (*a*) and any part of the fracture is more than $\frac{3}{4}$ in. from the center of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

(*b*) If the results of the physical test for any lot[1] do not conform to the requirements specified, such lot may be reheat-treated, but not more than twice. Retests of an additional specimen from the same lot[1] shall be made and shall conform to the requirements specified in Sections 9 and 11.

WORKMANSHIP AND FINISH

Workmanship

13. The castings shall be made in a workmanlike manner, and shall conform substantially to the dimensions on drawings furnished by the purchaser before manufacture is started; or to the dimensions of the pattern supplied by the purchaser, if no drawing has been provided.

Finish

14. (*a*) The castings shall be free from injurious defects.

(*b*) Minor defects which do not impair the strength of the castings may, with the consent of the purchaser's inspector, be welded by an approved process. The defects shall first be cleaned out to solid metal; and after welding, the castings shall be heat-treated to relieve cooling stresses and/or strains caused by fusion, if required by the purchaser's inspector.

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[1] By "lot" is meant all castings from each melt in each heat treatment charge.

MARKING

Marking

15. The manufacturer's name or identification mark and the specified pattern number shall be cast on all castings, excepting those of such small size as to make such marking impracticable. In addition, the numbers of the melts used for pouring the castings shall be stamped on all castings individually weighing 300 lb. or more.

INSPECTION AND REJECTION

Inspection

16. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of castings ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the castings are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection

17. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with these specifications shall be reported within five working days from the receipt of samples.

(*b*) Castings which show injurious defects subsequent to their acceptance at the manufacturer's works shall be rejected, and the manufacturer shall be notified promptly of such rejection.

Rehearing

18. Samples which represent rejected castings, tested in accordance with these specifications, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

SUPPLEMENT M, FOR MARINE CASTINGS

Grade

19. All castings shall be of the Regular Grade, Class B.

Number of Tension and Bend Tests for Special Castings

20. (*a*) One tension and one bend test shall be made from test bars representing each stern frame, stern post, twin screw spectacle frame, propeller shaft strut, rudder, steering quadrant, tiller, stem, and anchor; and from such other castings as may be specified before placing the order.

(*b*) When a casting is made from more than one melt, four tension and four bend tests shall be made to represent each casting.

Bend Tests

21. (*a*) Specimens for the bend test shall be smoothly machined to measure 1 by $\frac{1}{2}$ in. in cross-section, with the corners rounded to a radius not exceeding $\frac{1}{16}$ in. The length of the bend test specimen shall be not less than 8 in.

(*b*) The bend test shall be made by applying pressure gradually to one or both ends of the specimen described in Paragraph (*a*), at room temperature. Steel of the Regular Grade, Class B, shall stand being bent cold through at least 120 deg. around a pin 1 in. in diameter without cracking on the outside of the bent portion.

Percussion Tests

22. (*a*) A percussion test shall be made on each stern frame, stern post, twin screw spectacle frame, propeller shaft strut, rudder, steering quadrant, tiller, stem, and anchor, and on such other castings as may be specified before placing the order.

(*b*) In making the percussion test, the casting shall be suspended and subjected to severe blows from a hand hammer on all members chosen by the purchaser's inspector for this procedure. If any visible defect develops as the result of the percussion test, the purchaser's inspector shall have the right to reject the casting, to authorize welding or other repair work, or to accept the material.

SUPPLEMENT R, FOR RAILROAD CASTINGS

Number of Tension Tests for Special Castings

23. A sufficient number of test bars for tension test specimens shall be cast attached to (and near each end of) each locomotive frame, to each locomotive cylinder, to each locomotive wheel center,

and to such other castings as may be specified before placing the order. These test bars shall remain attached to the castings throughout heat treatment and until the castings are presented for inspection, unless separate heat treatment of the test bars is authorized by the purchaser. Tension test specimens machined from these test bars as prescribed in Section 10 (*c*) shall conform to the physical requirements specified in Section 9 (*a*).

Number of Tests for Small Orders

24. In the case of small orders for bolsters, truck sides, draft arms, yokes, and castings weighing over 180 lb. each, when it is not feasible to produce in one melt more than five castings of any kind described in this section, the physical properties as required in Section 9 (*a*) shall be determined from a test bar cast attached to some other casting of the same melt, or cast separately, if authorized by the purchaser.

Special Marking

25. All bolsters, truck sides, locomotive frames, locomotive wheel centers, locomotive cylinders, and similar castings shall have numbers cast on them, indicating the month and the year when made. The locations and sizes for such numbers shall be agreed upon between the manufacturer and the purchaser's inspector.

TENTATIVE SPECIFICATIONS

FOR

ALLOY-STEEL CASTINGS FOR STRUCTURAL PURPOSES[1]

A.S.T.M. Designation: A 148 - 33 T

This is a Tentative Standard, published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1933.

Scope

1. These specifications cover alloy-steel castings intended for use where mechanical stresses unaccompanied by high temperatures predominate. Three classes of castings are covered: namely,

Class A.—Castings of two grades, which shall be full annealed (Note 1).

Class B.—Castings of three grades, which may be normalized, or normalized and tempered or drawn (Note 2).

Class C.—Castings of three grades, which may be liquid quenched and tempered or drawn (Note 3).

NOTE 1.—The tension requirements for Class A castings are intended to apply to castings of such design and/or dimensions that they may be regarded as unsuitable for any method of heat treatment other than one that includes slow furnace cooling from above the critical temperature.

NOTE 2.—The tension requirements for Class B castings are intended to apply to castings regarded as suitable in design and/or dimensions for ordinary air cooling from above the critical temperature, as by normalizing. Such air cooling is a safe procedure for the great majority of alloy-steel castings intended for structural purposes, and usually develops the highest tensile strength and yield point values that can be obtained from the material by any method of heat treatment, except liquid quenching.

NOTE 3.—The tension requirements for Class C castings are intended to apply to castings regarded as suitable in composition, design, and/or dimensions for rapid cooling, as by liquid quenching, when such cooling is followed by a drawing or tempering operation. This combination of treatments generally develops the highest tensile strength and yield point values inherent in the material.

MANUFACTURE

Process

2. The steel shall be made by one or more of the following processes: open-hearth, electric-furnace, converter or crucible.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. H. P. Bigler, Secretary of Committee A-1 on Steel, Rail Steel Bar Assn., 33 N. La Salle St., Chicago, Ill.

Heat Treatment

3. (*a*) *Class A.*—Class A castings shall be heat treated by full annealing. This treatment may be applied one or more times, at the option of the manufacturer. The procedure for full annealing shall consist of allowing the castings to cool after pouring, to a temperature below the critical range, reheating to the proper temperature and for the required time as a preliminary procedure for the ultimate refinement of the grain, and cooling thereafter slowly in the furnace. The castings shall not be removed from the furnace until the pyrometer shows that the furnace charge has fallen uniformly to a temperature as low as 500 F. (260 C.).

(*b*) *Class B.*—Class B castings shall be heat treated by full annealing or by normalizing, at the option of the manufacturer. Also at his option, either or both of these treatments may be applied one or more times. The procedure for normalizing shall consist of allowing the castings to cool after pouring, to a temperature below the critical range, reheating to the proper temperature and for the required time as a preliminary procedure for the ultimate refinement of the grain, and cooling in still air at room temperature. At the option of the manufacturer, the normalizing treatment may be followed by a tempering or drawing treatment at a temperature below the critical range, but not less than 400 F. (204 C.). When cooling, Class B castings shall not be quenched in or sprayed with a liquid, nor be subjected to a mechanical air blast, except when mutually agreed upon between the manufacturer and purchaser.

(*c*) *Class C.*—Class C castings shall be heat treated by full annealing, or by normalizing, or by heating above the critical temperature followed by rapid cooling, at the option of the manufacturer. Also at his option, any or all of these treatments may be followed by a supplementary heating and a rapid cooling. The rapid cooling may be accomplished by quenching the castings in or spraying them with a liquid, or by subjecting them to a mechanical air blast. Any or all of these heating and cooling operations may be performed one or more times, at the option of the manufacturer. After the final rapid cooling by quenching, spraying, or air blasting, the castings shall be tempered or drawn at a temperature of 400 F. (204 C.) or over, to relieve cooling stresses. Castings that are liquid quenched, excepting those of very simple light-section design, shall be removed from the quenching bath before they attain room temperature, and shall be placed in a furnace for tempering or drawing immediately following removal from the quenching bath.

Temperature Control

4. Furnace temperatures for heat treating shall be controlled effectively by pyrometers.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition

5. (*a*) The steel shall conform to the following maximum requirements as to chemical composition:

Phosphorus, per cent	0.05
Sulfur, per cent	0.06

(*b*) Unless otherwise specified, the content of carbon, silicon, manganese, and other alloying elements shall be selected by the manufacturer to meet the physical properties specified.

(*c*) When specifically requested by the purchaser, analysis for all elements intentionally present in the steel shall be made by the manufacturer and furnished to the purchaser. The results of this analysis shall not be used as a basis for rejection, excepting in the case of a definite agreement as to composition other than that specified in Paragraph (*a*).

Ladle Analyses

6. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of the elements specified in Section 5 (*a*). This analysis shall be made from drillings taken at least $\frac{1}{4}$ in. beneath the surface of a test ingot obtained during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 5 (*a*).

Check Analyses

7. An analysis may be made by the purchaser from the broken tension test specimen or from a casting representing each melt. The chemical composition thus determined shall conform to the requirements specified in Section 5 (*a*). Drillings for analysis shall be taken not less than $\frac{1}{4}$ in. beneath the surface, in such a manner as not to impair the usefulness of the casting.

PHYSICAL PROPERTIES AND TESTS

Tension Tests

8. (*a*) Steel used for the castings shall conform to the following minimum requirements as to tensile properties:[1]

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[1] Because it has come to the attention of Committee A-1 on Steel that the intent of tension test requirements in some specifications has at times been misinterpreted, the committee wishes to make it clear that it is not intended that a maximum limit shall be placed on any tensile property required in these specifications.

		TENSILE STRENGTH, LB. PER SQ. IN.	YIELD POINT, LB. PER SQ. IN.	ELONGATION IN 2 IN., PER CENT	REDUCTION OF AREA, PER CENT
Class A	Grade 1	75 000	40 000	24	35
	Grade 2	85 000	53 000	22	35
Class B	Grade 1	85 000	55 000	22	40
	Grade 2	90 000	60 000	22	45
	Grade 3	100 000	65 000	18	30
Class C	Grade 1	90 000	65 000	20	50
	Grade 2	120 000	100 000	14	35
	Grade 3	150 000	125 000	10	25

(*b*) The yield point shall be determined by the drop of the beam or halt in the gage of the testing machine, or by an extensometer, at a cross-head speed not to exceed $\frac{1}{8}$ in. per minute. The tensile strength shall be determined at a speed of head not to exceed $1\frac{1}{2}$ in. per minute.

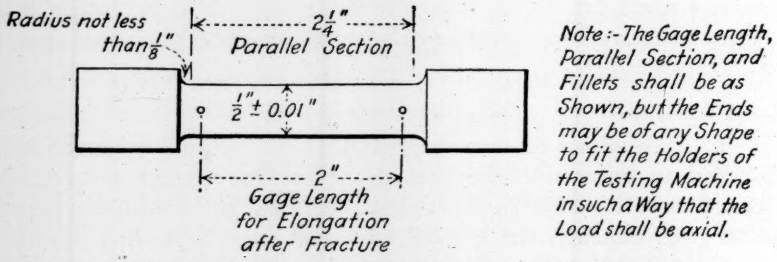
Radius not less than $\frac{1}{8}$"
$2\frac{1}{4}$"
Parallel Section
$\frac{1}{2}$" ± 0.01"
2"
Gage Length for Elongation after Fracture
Note:- The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.

FIG. 1.—Standard 2-in. Gage Length Tension Test Specimen.

Bend Tests

9. (*a*) Bend tests for Class A castings shall be made only when specified, but shall not be required for Class B and Class C castings.

(*b*) When a bend test is specified, the test specimen shall stand being bent cold through 120 deg. around a pin 1 in. in diameter without cracking on the outside of the bent portion.

Test Specimens

10. (*a*) Tension test specimens and, when specified, bend test specimens shall be prepared from test bars attached to castings where practicable. If the design of the casting is such that test bars should not be attached thereon, the test bars shall be cast attached to special blocks. Test bars from which test specimens are to be prepared shall remain attached to the castings or blocks they represent until submitted for inspection, and shall be heat treated with the castings. Test bars shall be provided in sufficient number to furnish specimens for the tests required in Section 11.

(*b*) If mutually satisfactory to the manufacturer and the purchaser's inspector, test specimens may be cut from heat-treated castings instead of from test bars.

(*c*) Tension test specimens shall conform to the dimensions shown in Fig. 1. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial.

(*d*) Bend test specimens, when specified, shall be machined to 1 by $\frac{1}{2}$ in. in sections with the corners rounded to a radius of not over $\frac{1}{16}$ in.

Number of Tests

11. (*a*) One tension test and, when specified, one bend test shall be made from each melt in each heat treatment charge.

(*b*) If any test specimen shows defective machining or develops flaws, it may be discarded, in which case another specimen from the same lot[1] shall be substituted.

Retests

12. (*a*) If the results of the physical test for any lot[1] do not conform to the requirements specified, such lot may be reheat-treated, but not more than twice. Retests of an additional specimen from the same lot[1] shall be made and shall conform to the requirements specified in Sections 8 and 9.

(*b*) If the percentage of elongation of any tension test specimen is less than that specified in Section 8 (*b*) and any part of the fracture is more than $\frac{3}{4}$ in. from the center of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

WORKMANSHIP AND FINISH

Workmanship

13. The castings shall conform substantially to the shapes and sizes indicated by the patterns and drawings submitted by the purchaser.

Finish

14. (*a*) The castings shall be free from injurious defects.

(*b*) Defects which do not impair the strength of the castings may be welded by an approved process. The defects shall be cleaned out to solid metal before welding, and when required by the purchaser's inspector shall be submitted to him in this condition for approval. Also when required by the purchaser's inspector, castings shall be given a simple and uniform heat treatment to relieve cooling stresses after welding.

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[1] By "lot" is meant all castings from each melt in each heat treatment charge.

INSPECTION AND REJECTION

Inspection

15. (*a*) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the castings ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the castings are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

(*b*) If surface inspection of castings in the green state is required, this shall be specified in the order.

Rejection

16. (*a*) Any rejection based on tests indicating chemical composition differing from that prescribed shall be reported within five working days from the receipt of samples by the purchaser.

(*b*) Samples tested by the purchaser and causing rejection of castings on account of improper chemical composition shall be preserved for two weeks from the date of transmitting the report to the manufacturer regarding such rejection. In case of dissatisfaction with the results of any such tests, the manufacturer may make claim within the two weeks' period for a rehearing.

(*c*) Castings which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified immediately.

TENTATIVE SPECIFICATIONS

FOR

NORMALIZED AND TEMPERED ALLOY-STEEL FORGINGS FOR LOCOMOTIVES[1]

A.S.T.M. Designation: A 133 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

Issued, 1931; Revised, 1933.

Scope. 1. (*a*) These specifications cover two classes of normalized and tempered alloy-steel forgings for use in locomotive construction.

(*b*) The characteristics of the two classes are as follows:

Class A.—Medium tensile strength with high yield point and high ductility.

Class. B.—High tensile strength with considerable ductility.

MANUFACTURE

Process. 2. The steel shall be made by either or both the following processes: open-hearth or electric-furnace.

Discard. 3. A sufficient discard shall be made from each ingot to secure freedom from injurious piping and undue segregation.

Prolongations for Tests. 4. Unless otherwise specified, for purposes of test, at least 20 per cent of the forgings shall be provided with prolongations, or at the manufacturer's option, a forging may be selected.

Boring. 5. If boring is required in the case of axles, shafts and similar forgings, it shall be performed before heat treatment, and the diameter of the hole, unless otherwise specified, shall be at least 20 per cent of the maximum outside diameter or thickness of the forging, exclusive of collars and flanges.

Heat Treatment. 6. (*a*) *Cooling.*—After forging, the objects shall be allowed to cool to a temperature below the critical range, under suitable conditions to prevent injury by too rapid cooling.

(*b*) *Normalizing.*—For normalizing, the forgings shall be uniformly reheated to a proper temperature to refine the grain, and after being held a sufficient length of time at this temperature, shall be withdrawn from the furnace and allowed to cool uniformly in still air, protected from rain or snow, to a temperature below the critical range. A group of forgings thus heated shall be known as a "normalizing charge."

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. H. P. Bigler, Secretary of Committee A-1 on Steel, Rail Steel Bar Assn., 33 N. La Salle St., Chicago, Ill.

(*c*) *Tempering.*—For tempering, after normalizing as described in Paragraph (*b*), the forgings shall be uniformly reheated to a temperature below the critical range, and after being held a proper time at this temperature shall be allowed to cool uniformly either in the furnace or in the atmosphere protected from rain or snow. A group of forgings thus treated shall be known as a "tempering charge."

CHEMICAL PROPERTIES AND TESTS

Chemical Composition.

7. (*a*) The steel shall conform to the following requirements as to chemical composition:

Phosphorus, maximum, per cent	0.045
Sulfur, maximum, per cent	0.050

(*b*) The composition other than phosphorus and sulfur shall be agreed upon by the manufacturer and the purchaser.

NOTE.—Compositions which have been used successfully to give the physical properties specified in Section 10 are as follows:

	CLASS A	CLASS B
Carbon, per cent	0.20 to 0.30	0.42 to 0.57
Manganese, per cent	0.80 to 1.00	0.70 to 0.95
Silicon, per cent	not less than 0.15	not less than 0.15
Nickel, per cent	2.50 to 3.00	not over 0.25
Chromium, per cent	not over 0.40	not over 0.40
Vanadium, per cent	not over 0.05	not less than 0.15

Ladle Analyses.

8. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon and the elements specified in Section 7. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 7.

Check Analyses.

9. An analysis may be made by the purchaser from a forging representing each melt. The chemical composition thus determined shall conform to the requirements specified in Section 7. Drillings for analysis may be taken from the forging or from a full-size prolongation of the same, at any point midway between the center and surface; or turnings may be taken from a test specimen.

PHYSICAL PROPERTIES AND TESTS

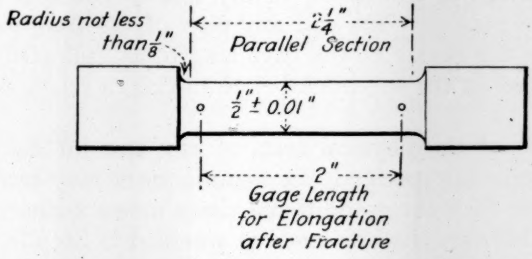
Tension Tests.

10. (*a*) The forgings shall conform to the following minimum requirements as to tensile properties:

	Class A Not Over 14 in. in Diameter, or Thickness, 7-in. Maximum Wall	Class B Not Over 14 in. in Diameter, or Thickness, 7-in. Maximum Wall
Tensile strength, lb. per sq. in.	80 000	90 000
Yield point, lb. per sq. in.	55 000	58 000
Elongation in 2 in., per cent	28	22
Reduction of area, per cent	56	42

(*b*) The yield point shall be determined by the drop of the beam or halt in the gage of the testing machine. The speed of the testing machine shall be such that when running light the crosshead speed shall not be less than $\frac{1}{16}$ in. nor more than $\frac{1}{8}$ in. per minute.

(*c*) Tests of forgings shall be made only after final treatment.


Radius not less than $\frac{1}{8}$"
$2\frac{1}{4}$"
Parallel Section
$\frac{1}{2}$" ± 0.01"
2"
Gage Length for Elongation after Fracture

Note:–The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.

FIG. 1.—Standard 2-in. Gage Length Tension Test Specimen.

Bend Tests.

11. If specified by the purchaser, bend tests shall be made as follows:

The test specimen shall stand being bent cold through 180 deg. around a pin $\frac{1}{2}$ in. in diameter without cracking on the outside of bent portion.

Test Specimens.

12. (*a*) Tension and bend test specimens shall be taken from a full-size prolongation of any forging. For forgings with large ends or collars, the prolongation may be of the same cross-section as that of the forging back of the large end or collar. The specimens may be taken from the forging itself with a hollow drill if approved by the purchaser.

(*b*) The axis of the specimen shall be located at any point midway between the center and surface of solid forgings, and at any point midway between the inner and outer wall surfaces of bored forgings, and shall be parallel to the axis of the forging in the direction in which the metal is most drawn out.

(*c*) Tension test specimen shall conform to the dimensions shown in Fig. 1. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial.

(*d*) Bend test specimens shall be ½ in. square in section with corners rounded to a radius not over $\frac{1}{16}$ in., and need not exceed 6 in. in length.

Number of Tests. 13. (*a*) One tension test, and when specified one bend test, shall be made from each tempering charge. If more than one normalizing charge is represented in a tempering charge, one tension test, and when specified one bend test, shall be made from each normalizing charge. If more than one melt is represented in a normalizing charge one tension test, and when specified one bend test, shall be made from each melt.

(*b*) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(*c*) If the percentage of elongation of any test specimen is less than that specified in Section 7 (*a*) and any part of the fracture is more than ¾ in. from the center of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

Retests. 14. If the results of the physical tests of any test lot do not conform to the requirements specified, the manufacturer may retreat such lot, but not more than three additional times unless authorized by the purchaser, and retests shall be made as specified in Section 13.

WORKMANSHIP AND FINISH

Workmanship. 15. The forgings shall conform to the sizes and shapes specified by the purchaser. Axles, shafts, and similar forgings, unless otherwise specified, shall be rough turned all over with an allowance of ⅛ in. on the surface for finishing. In centering, 60-deg. centers with clearance drilled for points shall be used.

Finish. 16. The forgings shall be free from injurious defects and shall have a workmanlike finish.

MARKING

Marking. 17. Identification marks shall be legibly stamped on each forging and on each test specimen. The purchaser shall indicate the location of such identification marks.

INSPECTION AND REJECTION

Inspection. 18. (*a*) The inspector representing the purchaser shall have free entry at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the forgings ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the forgings are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

(*b*) The purchaser may make the tests to govern the acceptance or rejection of the forgings in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

Rejection.

19. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 18 (*b*) shall be reported within five working days from the receipt of samples.

(*b*) Forgings which show injurious defects while being finished by the purchaser will be rejected, and the manufacturer shall be notified.

Rehearing.

20. Samples tested in accordance with Section 18 (*b*) which represent rejected forgings, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

TENTATIVE SPECIFICATIONS

FOR

HEAT-TREATED STEEL ELLIPTICAL SPRINGS[1]

A.S.T.M. Designation: A 147 – 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

Issued, 1933.

Scope

1. These specifications cover heat-treated carbon-steel or alloy-steel elliptical springs for railway use. They may also be used for miscellaneous elliptical and special flat springs.

Chemical Properties and Tests

Basis of Purchase

2. (*a*) Except as may be specified in accordance with Paragraph (*b*), the springs shall be made of carbon-steel bars conforming to the following requirements as to chemical composition:

Carbon, per cent	0.90 to 1.05
Manganese, per cent	0.25 to 0.50
Phosphorus, max., per cent	0.05
Sulfur, max., per cent	0.05
Silicon, min., per cent	0.15

(*b*) Other types of steel, such as silico-manganese steel conforming to the requirements of the Standard Specifications for Silico-Manganese-Steel Bars for Railway Springs (A.S.T.M. Designation: A 59) and chrome-vanadium steel conforming to the Standard Specifications for Chrome-Vanadium-Steel Bars for Railway Springs (A.S.T.M. Designation: A 60) of the American Society for Testing Materials,[2] may be used when mutually agreed upon by the manufacturer and purchaser.

(*c*) The bands of the springs shall be made either of wrought iron conforming to the requirements of the Standard Specifications for Refined Wrought-Iron Bars (A.S.T.M. Designation: A 41)[3] or of "dead-soft" open-hearth-steel bars conforming to the Standard Specifications for Commercial Quality Hot-Rolled Bar Steels (A.S.T.M. Designation: A 107)[1] or, subject to mutual agreement between the manufacturer and purchaser, may be made of steel castings conforming to the requirements of Class B, soft grade, of the Standard Specifications for Carbon-Steel Castings (A.S.T.M. Designation: A 27)[2] of the American Society for Testing Materials.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. H. P. Bigler, Secretary of Committee A-1 on Steel, Rail Steel Bar Assn., 33 N. La Salle St., Chicago, Ill.

[2] 1933 Book of A.S.T.M. Standards, Part I, pp. 150, 148.

[3] *Ibid.*, p. 433.

Check Analysis

3. (*a*) An analysis may be made by the purchaser from a sample representing each size of spring steel involved. The chemical composition thus determined shall conform to the requirements specified in Section 2 (*a*) or (*b*) for the type of steel agreed upon.

(*b*) Drillings for chemical analysis shall be taken from pieces sheared from the bars during the process of manufacture, and not from a finished spring, unless otherwise agreed upon, and shall be selected from thoroughly mixed total drillings obtained by passing nearly through the section of the bar after discarding the surface drillings.

MANUFACTURE

Forming

4. The spring leaves, after going through the preliminary operation of fabrication, shall be heated slowly and uniformly to the lowest temperatures at which the steel will work satisfactorily; in no case to exceed 1750 F. (955 C.) for the steel specified in Section 2 (*a*); and formed to the desired shape. The leaves shall then be allowed to cool slowly in the air to at least a distinct black color.

Heat Treatment

5. (*a*) The spring leaves, after forming and cooling, shall be reheated uniformly to a temperature sufficient to refine the grain and quenched in an ample volume of oil or other quenching medium. During the quenching the leaves shall be kept completely submerged until their temperature has been reduced to approximately 300 F. (149 C.) and no flashing shall take place on removal from the bath.

(*b*) Following the quenching as rapidly as may be possible the leaves shall be uniformly drawn back at a temperature below the critical but sufficiently high and for a sufficient time to produce a proper draw back or tempering effect.

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[1] 1933 Book of A.S.T.M. Standards, Part I, p. 93.

[2] *Ibid.*, p. 229.

Design

6. (*a*) The springs shall conform, within the limitations herein specified, to approved drawings showing the design, dimensions, and the physical requirements. The manufacturer shall have the right to criticize the fiber stresses involved in any design.

(*b*) Dimensions which affect the contour only and do not affect the interchange or service of the springs need only be approximated. This covers end clips, leaf spacing, full-length leaves, shape of leaf ends, etc.

(*c*) The springs shall have the leaves properly graduated in length, properly bent and fitted to reasonably true circular arcs.

NOTE.—It is suggested that all leaves, other than the main leaf and those extending to the full length of the main leaf, have their ends tapered in thickness, or spear pointed by bevelling in width on each side, or otherwise suitably shaped to insure adequate flexibility of the leaf tips.

(*d*) The physical tests and tolerances required in these specifications are intended for springs of standard railroad designs. Other tests or tolerances when required for springs of special design and indicated on the drawings may be substituted for those specified herein, when mutually agreed upon by the manufacturer and purchaser.

PHYSICAL PROPERTIES AND TESTS

Number of Tests

7. (*a*) From each lot of springs, which conform to the requirements of Section 6, the inspector shall select for physical test at least 25 per cent to be tested in accordance with the compression method as described in Section 8 (*d*) or if so specified, in accordance with the release method as described in Section 8 (*e*).

(*b*) If any of the springs representing a lot fail to conform to the requirements of Section 8 (*d*) or (*e*) as specified, but at least half of the springs representing a lot do meet these requirements, each spring of the lot shall be tested and those that meet the requirements shall be accepted. If more than half of the springs representing a lot fail to conform to the requirements of Section 8 (*d*) or (*e*) as specified, the lot represented shall be rejected.

Order of Tests

(*c*) The physical tests specified in Paragraphs (*a*) to (*f*), of Section 8, modified if necessary to conform to the requirements of Sections 10 and 11, shall be determined in the order specified. The springs shall not be rapped or otherwise disturbed during the test. The ends of half-elliptical springs shall be supported on roller or swing bearings.

(*d*) The tension and other tests of band material specified in Section 2 (*c*) may be made by the purchaser. The physical properties thus determined shall conform to the grade of material specified in accordance with Section 2 (*c*).

(*e*) In determining the loaded height and the loaded length of the springs, the compression method of test described in Section 8 (*d*) shall be used unless the release method described in Section 8 (*e*) is specified.

Physical Tests

8. (*a*) *Free Height.*—The free height is the height of the spring after a preliminary test load of one and one-half times the specified working load has been applied and fully released.

(*b*) *Loaded Height.*—The loaded height is the height of the spring when the specified working load is supported by the spring.

(*c*) *Loaded Length.*—The loaded length is the length of the spring when the specified working load is supported by the spring.

Compression Method

(*d*) For the compression method of test the load shall be applied gradually and in such a way that the specified working load shall not be exceeded. If it is exceeded, the load shall be released to not more than one-half the specified working load and then increased to the specified working load.

The loaded height and the loaded length shall be measured when the spring is in this position.

The load shall be increased to one and one-half times the specified working load. The load shall then be fully released and the height measured as free height after test.

Release Method

(*e*) For the release method of test a load one and one-half times the specified working load shall be applied and then slowly released to the specified working load. If released to less than the specified working load, the load shall again be raised to one and one-half times the specified working load and then released to the specified working load.

The loaded height and the loaded length shall be measured when the spring is in this position. The load shall then be fully released and the height measured as free height after test.

(*f*) *Permanent Set.*—Permanent set is the difference, if any, between the free height and the free height after test.

Tolerances

9. (*a*) Springs shall conform to the following tolerances when tested in accordance with Section 8 (*d*) or (*e*), as specified:

Free Height.—Special tolerances for free height may be agreed upon by the manufacturer and purchaser.

NOTE.—The function of an elliptical spring being to support a given load at a desired height, the free height becomes of minor importance other than an approximate measure of flexibility, therefore, the free height is not included in these specifications as a critical dimension for check and inspection.

Loaded Height:

Compression method.—The loaded height shall not be less, but may be $\frac{3}{8}$ in. more, than that specified.

Release method.—The loaded height shall not be more, but may be $\frac{3}{8}$ in. less, than that specified.

Loaded Length.—The loaded length shall not vary more than $\frac{1}{4}$ in. from that specified.

Permanent Set.—The permanent set shall not exceed $\frac{1}{32}$ in. If there is some permanent set, though not exceeding $\frac{1}{32}$ in., the load of one and one half times the specified working load shall be applied and fully released two additional times, after which there shall be no further permanent set.

(*b*) *Band Tolerances.*—The bands of the springs shall not vary more than $\frac{1}{8}$ in. in width of straps from that specified, nor shall the thickness of the straps be more than $\frac{1}{32}$ in. less than that specified.

The springs shall not vary in width across the bands more than $\frac{1}{8}$ in. for a single unit spring. An additional $\frac{1}{16}$ in. will be permitted for each additional unit making up a multiple unit spring.

(*c*) *Bar Tolerances.*—The bars shall conform to the following requirements as to permissible variations in width and thickness:

FLATS

	VARIATIONS IN WIDTH, IN.		VARIATIONS IN THICKNESS, IN.			
			UP TO $\frac{3}{8}$ IN., INCLUSIVE		OVER $\frac{3}{8}$ TO $\frac{5}{8}$ IN., INCLUSIVE	
	OVER	UNDER	OVER	UNDER	OVER	UNDER
1 to 2 in., incl........	0.030	0.015	0.015	0.005	0.015	0.010
Over 2 to 4 in., incl...	0.047	0.015	0.015	0.005	0.015	0.010
Over 4 to 6 in., incl...	0.062	0.032	0.015	0.005	0.015	0.010

ROUNDS AND SQUARES

	VARIATIONS IN DIAMETER OR THICKNESS, IN.	
	OVER	UNDER
Up to $\frac{1}{2}$ in., incl............................	0.007	0.007
Over $\frac{1}{2}$ to 1 in., incl.........................	0.010	0.010
Over 1 to 2 in., incl....	0.016	0.016

Testing Stress

10. (*a*) The properties and methods of testing specified in Section 8 have been established on the assumption that the maximum fiber stress developed during the tests shall not exceed 135,000 lb. per sq. in. for the grade of steel specified in Section 2 (*a*). This stress is given solely as a limiting stress not to be exceeded in testing and is not intended as a guide in the design of springs, as the proper working fiber stress will depend upon the class of the spring and upon the service for which it is intended.

In the case of alloy-steel springs, practice has not been sufficiently well established to enable definite fiber stresses to be given. Unless otherwise mutually agreed upon by the manufacturer and purchaser, alloy-steel springs shall be tested under the conditions as to fiber stress specified herein.

(*b*) Unless otherwise mutually agreed upon by the manufacturer and purchaser, springs that do not meet the conditions of Paragraph (*a*) shall not be subjected to the test load of one and one-half times the specified working load as required by Section 8, but shall be submitted, in lieu thereof, to a test load which corresponds to a maximum fiber stress of 135,000 lb. per sq. in. as determined in Section 12. The permanent set measured after application and release of such test load shall conform to the requirements of Section 9.

Load not Specified

11. If springs are ordered to free height and length only, and no working load and no loaded dimensions are specified, the tests specified in Section 8 shall be made, using instead of the "specified working load" the load which corresponds to a fiber stress of 75,000 lb. per sq. in. as determined by Equation (1) in Section 12, and instead of the requirements of Section 9 (*e*), the free height shall not vary more than $\frac{3}{16}$ in. from that specified.

Test Loads

12. (*a*) The test load corresponding to a maximum fiber stress of 135,000 lb. per sq. in. shall be calculated from the following equation:

$$P = \frac{2Snbh^2}{3L} \qquad (1)$$

where P = the test load in pounds;

S = the stress at the most strained fiber in pounds per square inch;

n = the number of leaves in a half elliptic spring or the number of leaves in one half of a full elliptic spring;

b = the width of the leaves in inches;
h = the thickness of the leaves in inches; and
L = the distance between the centers of supports in inches when the spring is supporting the specified working load.

(*b*) Table I shows the loads in pounds corresponding to a maximum fiber stress of 135,000 lb. per sq. in. for one leaf 1 in. in width, of various thicknesses and in various lengths between centers of the supports.

(*c*) The total test load in pounds for any spring is found by multiplying the value from Table I by the product of the width of leaves times the number of leaves.

TABLE I.—LOAD IN POUNDS FOR ONE LEAF 1 IN. IN WIDTH AT MAXIMUM STRESS OF 135,000 LB. PER SQ. IN.

Length of Spring, in	Thickness of Leaf, in.							
	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{11}{32}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$
20	281	439	531	...	...	...	...	...
22	255	399	483	575	...	...	...	...
24	234	366	443	527	...	...	...	...
26	216	338	409	486	662	...	..	...
28	201	314	379	451	615	803	...	...
30	187	293	354	421	574	750	...	...
32	175	274	332	395	538	703	889	...
34	...	258	312	372	506	661	837	...
36	...	244	295	351	478	625	791	976
38	...	...	279	333	453	592	749	925
40	...	...	265	316	430	562	712	878
42	...	...	...	301	410	535	678	837
44	...	...	...	287	391	511	647	799
46	...	...	...	...	374	489	619	764
48	...	...	...	...	359	468	593	732
50	...	...	...	...	345	450	569	703
52	...	...	...	...	...	432	547	676
54	...	...	...	...	...	416	527	651
56	...	...	...	...	...	401	508	627
58	...	...	...	...	...	...	491	606
60	...	...	...	...	...	...	475	586

WORKMANSHIP AND FINISH

Workmanship and Finish

13. (*a*) The springs shall be submitted for inspection singly or grouped as may be shown on the drawings and shall meet the specified tests within the tolerances specified in Section 9.

(*b*) Springs shall be free from injurious surface defects and shall present a workmanlike appearance.

(*c*) All springs, after being assembled, shall be dipped in oil or painted to prevent rusting.

MARKING

Marking

14. (*a*) The name or brand of the manufacturer, the year and month of manufacture and, if specified, the purchaser's class number

shall be legibly stamped on each spring at a place not detrimental to the life or service of the spring.

(*b*) Any stamping by the inspector shall be so placed as not to be detrimental to the life or service of the spring.

INSPECTION AND REJECTION

Inspection

15. (*a*) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the springs ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the springs are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection

(*b*) Unless otherwise specified, any rejection based on tests made in accordance with Section 3 shall be reported within five working days from the receipt of samples.

Rehearing

(*c*) Samples tested in accordance with Section 3, which represent rejected springs, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

Reworking

(*d*) Any springs that fail to meet the requirements as to dimensions or physical tests may be again submitted after being reworked.

(*e*) Individual springs which, subsequent to inspection at the mills or elsewhere and their acceptance, show defects or imperfections will be rejected and shall be replaced by the manufacturer.

TENTATIVE SPECIFICATIONS

FOR

LAP-WELDED AND SEAMLESS STEEL PIPE FOR HIGH-TEMPERATURE SERVICE[1]

A.S.T.M. Designation: A 106 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED AS TENTATIVE, 1926; ADOPTED IN AMENDED FORM, 1929;
REISSUED AS TENTATIVE, 1933.

Scope

1. These specifications cover lap-welded and seamless steel pipe for 250, 300, 400, 600, 900 and 1500 lb. per sq. in. pressure and high temperatures (Note 1). Pipe ordered under these specifications shall be suitable for bending, flanging and similar forming operations (Note 2). Supplementary requirements of an optional nature are provided for seamless pipe intended for use in central stations having steam service pressures of 400 lb. per sq. in. or over and temperatures up to 750 F., or other applications where a superior grade of pipe is required. These supplementary requirements (Sections 20 to 22) call for additional tests to be made at the expense of the purchaser, and when desired shall be so stated in the order.

MANUFACTURE

Process

2. (*a*) The steel for lap-welded pipe shall be of good weldable quality made by the open-hearth process. The steel for seamless pipe may be made by either or both of the following processes: open-hearth or electric-furnace.

(*b*) Welded pipe 2 in. or over in nominal diameter shall be made by the lap-weld process. All pipe $1\frac{1}{2}$ in. or under in nominal diameter shall be made by the seamless process, and may be either hot finished or cold drawn and annealed.

(*c*) Unless otherwise specified, seamless pipe 2 in. or over in nominal diameter shall be furnished hot finished. When mutually agreed upon between the manufacturer and purchaser, cold drawn and annealed pipe may be furnished.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. H. P. Bigler, Secretary of Committee A-1 on Steel, Rail Steel Bar Assn., 33 N. La Salle St., Chicago, Ill.

These specifications are in effect a revision of, and replace the former Standard Specifications for Lap-Welded and Seamless Steel Pipe for High-Temperature Service (A.S.T.M. Designation: A 106 - 29), which standard was accordingly discontinued in 1933.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition

3. The steel for welded and seamless pipe shall conform to the following ladle analysis requirements as to chemical composition:

	WELDED	SEAMLESS		
	OPEN HEARTH	GRADE A	GRADE B	GRADE C
Manganese, per cent ...	0.30 to 0.60	0.30 to 0.60	0.35 to 1.50	0.35 to 1.50
Phosphorus, max., per cent	0.045	0.04	0.04	0.04
Sulfur, max., per cent ..	0.06	0.06	0.06	0.06
Carbon, max., per cent.	....	....	0.40[a]	[a]

[a] In case grade B or C pipe is to be joined by fusion welding, the purchaser may wish to stipulate the carbon content by special agreement; see recommendations included in the List of Specifications for Steel Suitable for Fusion Welding (A.S.T.M. Designation: A 151) of the American Society for Testing Materials.[1]

Check Analysis

4. (*a*) At the request of the purchaser's inspector, analyses of two pipes from each lot of 400 lengths or fraction thereof of each size 2 in. up to, but not including, 6 in., and from each lot of 200 lengths or fraction thereof of each size 6 in. or over, shall be made by the manufacturer from the finished pipe and shall conform to the requirements specified in Section 3.

(*b*) Drillings for analysis shall be taken from several points around each pipe selected for analysis.

PHYSICAL PROPERTIES AND TESTS

Tension Tests

5. (*a*) The material shall conform to the following minimum requirements as to tensile properties:

	WELDED	SEAMLESS		
	OPEN HEARTH	GRADE A (NOTE 2)	GRADE B	GRADE C
Tensile strength, lb. per sq. in..........	45 000	48 000[a]	62 000[a]	75 000[a]
Yield point, lb. per sq. in.............	25 000	30 000[a]	35 000[a]	45 000[a]
Elongation in 8 in., per cent............	22	......	......	......
Elongation in 2 in., per cent	......	30[a]	25[a]	20[a]

[a] For transverse tension tests, the material shall conform to these minimum tensile requirements except that the elongation in 2 in. shall be 25 per cent for grade A, 20 per cent for grade B, and 15 per cent for grade C seamless material.

(*b*) The yield point shall be determined by the drop of the beam or halt in the gage of the testing machine, or by other approved method.

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[1] 1933 Book of A.S.T.M. Standards, Part I, p. 77.

Hydrostatic Tests

6. Unless otherwise mutually agreed upon between the manufacturer and purchaser, each length of pipe shall be tested at the mill to the hydrostatic pressure specified in the following table, which pressure shall be maintained for not less than five seconds. Seamless pipe 12 in. and over in outside diameter, and all welded pipe shall be struck near both ends while under test pressure by a hammer exerting an energy of not less than 20 ft-lb. at the time of impact.

CLASS OF PIPE, STEAM SERVICE PRESSURE RATING AT 750 F., LB. PER SQ. IN.	STANDARD HYDROSTATIC TEST PRESSURE, LB. PER SQ. IN.
250	750
300	750
400	1000
600	1500
900	2000
1500	3000

Flattening Tests

7. (*a*) For welded pipe, the crop end cut from each end of each length of pipe shall be flattened between parallel plates with the weld located 90 deg. from the line of direction of the applied force, until opposite walls of the pipe meet. No opening in the weld shall take place until the distance between the plates is less than two thirds of the original outside diameter of the pipe. No cracks or breaks in the metal elsewhere than in the lap-weld shall occur until the distance between the plates is less than one third of the original outside diameter of the pipe. Evidence of laminations or burnt material shall not develop during the entire flattening process. When double-welded pipe is furnished on special order, the flattening test shall show no opening in the weld until the distance between the plates is less than one third of the original outside diameter of the pipe. Precautions shall be taken so that crop ends can be identified with respect to the length from which they are cut.

(*b*) For grade A seamless pipe over 2 in. in nominal diameter, a section of pipe not less than $2\frac{1}{2}$ in. in length shall be flattened between parallel plates until opposite walls of the pipe meet. No cracks or breaks in the metal shall occur until the distance between the plates is less than one third the outside diameter of the pipe, but in no case less than five times the thickness of the pipe wall. Evidence of laminations or burnt material shall not develop during the entire flattening process.

(*c*) For grades B and C seamless pipe over 2 in. in nominal diameter, a section of pipe not less than $2\frac{1}{2}$ in. in length shall be flattened between parallel plates until opposite walls of the pipe meet. No cracks or breaks in the metal shall occur until the distance between the plates is less than one half the outside diameter of the pipe, but in no case less than seven times the thickness of the pipe wall. Evidence of laminations or burnt material shall not develop during the entire flattening process.

Bend Tests

8. For grades A and B seamless pipe 2 in. or under in nominal diameter, a sufficient length of pipe shall stand being bent cold through 90 deg. around a cylindrical mandrel, the diameter of which is twelve times the nominal diameter of the pipe, without developing cracks. When ordered for close coiling (Note 2), the pipe shall stand being bent cold through 180 deg. around a cylindrical mandrel, the diameter of which is eight times the nominal diameter of the pipe, without failure. Grade C seamless pipe need not be subjected to the bend test.

Test Specimens

9. (*a*) Specimens cut longitudinally or in the case of seamless pipe, either longitudinally or transversely, shall be acceptable for the tension test. Tension specimens from welded pipe shall be taken at a point approximately 90 deg. from the weld.

(*b*) Longitudinal tension tests may be made in full section of the pipe up to the capacity of the testing machine. For larger sizes, the tension test specimens shall consist of strips cut from the pipe. The width of these specimens shall be 1½ in. and shall have a gage length of 8 in. for welded pipe and 2 in. for seamless pipe. For seamless pipe, when the wall thickness exceeds ¾ in., the A.S.T.M. standard ½-in. round specimen shall be used. Longitudinal tension specimens shall not be flattened between gage marks. The sides of specimens shall be parallel between gage marks.

(*c*) The transverse tension test may be made on seamless pipe 8 in. and over in nominal diameter. Specimens may be taken from a ring cut from the pipe or from sections resulting from the flattening tests. The specimen shall consist of a strip cut transversely from the pipe; the width of the specimen shall be 1½ in. and its gage length 2 in. When the pipe wall thickness exceeds ¾ in., the A.S.T.M. standard ½-in. round specimen shall be used. Specimens shall be flattened cold and shall be parallel between gage marks. At the option of the manufacturer, the transverse tension test specimen may be machined off on either surface provided not over 15 per cent of the nominal thickness is removed from either side.

NOTE.—The standard tension test specimens are described in the Standard Methods of Tension Testing of Metallic Materials (A.S.T.M. Designation: E 8) of the American Society for Testing Materials.[1]

(*d*) Test specimens for flattening and bend tests shall consist of sections cut from a pipe. Specimens for flattening tests shall be smooth on the ends and free from burrs, except when made on crop ends.

(*e*) All specimens shall be tested at room temperature.

Number of Tests

10. (*a*) *Welded.*—The longitudinal tension test specified in Section 5 shall be made on one pipe from each lot of 400 lengths or fraction thereof, of each size under 6 in., and from each lot of 200 lengths or fraction thereof, of each size 6 in. or over.

Each length of welded pipe shall be subjected to the hydrostatic test specified in Section 6.

The flattening test specified in Section 7 (*a*) shall be made on both crop ends cut from each length of welded pipe.

(*b*) *Seamless.*—One of either of the tests specified in Section 5 shall be made on one pipe from each lot of 400 lengths or fraction thereof, of each size under 6 in. and from each lot of 200 lengths or fraction thereof, of each size 6 in. or over.

Each length of seamless pipe shall be subjected to the hydrostatic test specified in Section 6.

The flattening test specified in Section 7 (*b*) or (*c*) shall be made on one pipe from each lot of 400 lengths or fraction thereof, of each size over 2 in., up to but not including 6 in., and from each lot of 200 lengths or fraction thereof, of each size 6 in. or over.

For grades A and B seamless pipe, 2 in. or under in nominal diameter, the bend test specified in Section 8 shall be made on one pipe from each lot of 400 lengths or fraction thereof of each size.

Retests

11. (*a*) If the results of any chemical or physical tests of any lot do not conform to the requirements specified in Sections 3, 4 (*a*), 5, 7, and 8, retests shall be made on additional pipes of double the original number from the same lot, each of which shall conform to the requirements specified.

(*b*) If the percentage of elongation of any tension test specimen is less than that specified in Section 5 (*a*) and any part of the fracture is more than $\frac{3}{4}$ in. from the center of the gage length of a 2-in. specimen, or is outside the middle third of the gage length of the 8-in. specimen, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed. If a specimen breaks in an inside or outside surface flaw, a retest shall be allowed.

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[1] 1933 Book of A.S.T.M. Standards, Part I, p. 949.

TABLE I.[a]—DIMENSIONS AND WEIGHTS OF LAP-WELDED AND GRADE-A-SEAMLESS STEEL PIPE[b] FOR HIGH-TEMPERATURE SERVICE.

250, 300, 400, 600, 900, AND 1500 LB. PER SQ. IN. STEAM SERVICE PRESSURE RATINGS AT A TEMPERATURE OF 750 F.[c]

NOTE.—Commonly stocked thicknesses are shown in **boldface type.**

Steam Service Pressure Rating[c,d] at 750 F		250 lb. Lap-welded		300 lb. Seamless		400 lb. Lap-welded		400 lb. Seamless		600 lb. Seamless		900 lb. Seamless		1500 lb. Seamless	
Hydrostatic Test[d]		750 lb.		750 lb.		1000 lb.		1000 lb.		1500 lb.		2000 lb.		3000 lb.	
Nominal Pipe Size in.	Outside Diameter, in.	Nominal Wall Thickness, in.	Weight per Linear Foot, Plain Ends, lb.	Nominal Wall Thickness,[e] in.	Weight per Linear Foot, Plain Ends, lb.	Nominal Wall Thickness, in.	Weight per Linear Foot, Plain Ends, lb.	Nominal Wall Thickness,[e] in.	Weight per Linear Foot, Plain Ends, lb.	Nominal Wall Thickness,[e] in.	Weight per Linear Foot, Plain Ends, lb.	Nominal Wall Thickness,[e] in.	Weight per Linear Foot, Plain Ends, lb.	Nominal Wall Thickness,[e] in.	Weight per Linear Foot, Plain Ends, lb.
½....	0.840	......	......	**0.109**	0.86	......	......	**0.109**	0.86	**0.147**	1.09	**0.147**	1.09	0.187	1.31
¾....	1.050	......	......	**0.113**	1.14	......	......	**0.113**	1.14	**0.154**	1.48	**0.154**	1.48	0.218	1.94
1.....	1.315	......	......	**0.133**	1.68	......	......	**0.133**	1.68	**0.179**	2.18	**0.179**	2.18	0.250	2.85
1¼....	1.660	......	......	**0.140**	2.28	......	......	**0.140**	2.28	**0.191**	3.00	**0.191**	3.00	0.250	3.77
1½....	1.900	......	......	**0.145**	2.72	......	......	**0.145**	2.72	**0.200**	3.64	**0.200**	3.64	0.281	4.86
2.....	2.375	**0.154**	3.66	**0.154**	3.66	**0.218**	5.03	**0.154**	3.66	**0.218**	5.03	**0.218**	5.03	0.343	7.45
2½....	2.875	**0.203**	5.80	**0.203**	5.80	**0.276**	7.67	**0.203**	5.80	**0.276**	7.67	**0.276**	7.67	0.375	10.0
3.....	3.500	**0.216**	7.58	**0.216**	7.58	**0.300**	10.3	**0.216**	7.58	**0.300**	10.3	**0.300**	10.3	0.437	14.3
3½....	4.000	**0.226**	9.11	**0.226**	9.11	**0.318**	12.5	**0.226**	9.11	**0.318**	12.5	**0.318**	12.5	......	......
4.....	4.500	**0.237**	10.8	**0.237**	10.8	**0.337**	15.0	**0.237**	10.8	**0.337**	15.0	0.437	19.0	0.531	22.6
5.....	5.563	**0.258**	14.7	**0.258**	14.7	**0.375**	20.8	**0.258**	14.7	**0.375**	20.8	0.500	27.1	0.625	33.0
6.....	6.625	**0.280**	19.0	**0.280**	19.0	**0.432**	28.6	**0.280**	19.0	**0.432**	28.6	0.562	36.4	0.718	45.3
8.....	8.625	**0.322**	28.6	**0.277**	24.7	**0.500**	43.4	**0.322**	28.6	**0.500**	43.4	0.593	50.9	0.906	74.7
10.....	10.75	**0.365**	40.5	**0.307**	34.3	**0.500**	54.8	**0.365**	40.5	0.593	64.4	0.718	77.0	1.125	116
12.....	12.75	0.406	53.6	**0.330**	43.8	0.562	73.2	0.406	53.6	0.687	88.6	0.843	108	1.312	161
14.....	14.0	0.437	63.3	0.375	54.6	0.593	85.0	0.437	63.3	0.750	107	0.937	131	1.406	190
16.....	16.0	0.500	82.8	0.375	62.6	0.656	108	0.500	82.8	0.843	137	1.031	165	1.562	241
18.....	18.0	0.562	105	0.437	82.0	0.718	133	0.562	105	0.937	171	1.156	208	1.750	304
20.....	20.0	0.593	123	0.500	105	0.812	167	0.593	123	1.031	209	1.250	251	1.937	374
24.....	24.0	0.687	171	0.562	141	0.937	231	0.687	171	1.218	297	1.500	361	2.312	536

[a] See Explanatory Note 3.

[b] While the thicknesses given in this table are theoretically ample to care for both bursting pressure and material removed in threading, it is recommended that where pipe is threaded, a weight at least equal to the 600-lb. class be used to furnish added mechanical strength.

[c] For ratings for power piping at temperatures from 500 to 850 F., see Table II, Adjusted Service Pressures for Power Piping at Temperatures Below and Above 750 F., appearing in Explanatory Note 1.

[d] All pressures in pounds per square inch gage.

[e] This column gives the recommended thickness of pipe made of Grade A material. With a few exceptions, the thicknesses given, when substituted in the formula for the classification of commercial pipe, developed by the Sectional Committee on Standardization of Dimensions and Material of Wrought-Iron and Wrought-Steel Pipe and Tubing, functioning under the procedure of the American Standards Association, A.S.A. Project No.; B 36, will show a lower stress than allowed by the A.S.M.E. Boiler Construction Code, or 9000 lb. per sq. in. at 750 F. When calculated by theoretically correct formulas, the stress for every pipe wall is within the limiting stress fixed by the Boiler Code. Where stresses calculated by the formula of Sectional Committee B 36 are slightly higher than 9000 lb. per sq. in., which would require assigning a commercial wall thickness out of proportion to the service conditions, no increase in wall thickness was provided if the stress when computed by theoretically correct formulas was found to be lower than 9000 lb. per sq. in.

(*c*) Should a crop end of a finished welded or seamless pipe fail in the flattening test, one retest may be made from the failed end. Pipe may be normalized either before or after the first test, but pipe shall be subjected to only two normalizing treatments.

(*d*) If any specimen shows defective machining or develops flaws not associated with the welding for lap-welded pipe, it may be discarded and another specimen substituted.

WEIGHTS, DIMENSIONS AND PERMISSIBLE VARIATIONS

Weights and Dimensions

12. (*a*) The nominal wall thicknesses and standard weights for pipe of various diameters are given in Table I.

(*b*) Nipples shall be cut from pipe of the same weight and quality described in these specifications.

Permissible Variations

13. (*a*) *Weight.*—The weight of any length of pipe shall not vary from that specified in Table I by more than 3.5 per cent under or 6.5 per cent over for the 250, 300, 400, 600 and 900 lb. per sq. in. standards, nor more than 3.5 per cent under or 10 per cent over for the 1500-lb. standard. Unless otherwise mutually agreed upon between the manufacturer and purchaser, pipe in sizes smaller than 4 in. may be weighed in convenient lots, pipe in sizes 4 in. and larger shall be weighed separately.

(*b*) *Diameter.*—Variations in outside diameter shall not exceed those shown in the following table:

NOMINAL PIPE SIZE	PERMISSIBLE VARIATIONS IN OUTSIDE DIAMETER UNDER	 OVER
$\frac{1}{8}$ to $1\frac{1}{2}$ in., inclusive	$\frac{1}{32}$ in. (0.031 in.)	$\frac{1}{64}$ in. (0.015 in.)
2 to 4 in., inclusive	$\frac{1}{32}$ in. (0.031 in.)	$\frac{1}{32}$ in. (0.031 in.)
5 to 8 in., inclusive	$\frac{1}{32}$ in. (0.031 in.)	$\frac{1}{16}$ in. (0.062 in.)
10 to 18 in., inclusive	$\frac{1}{32}$ in. (0.031 in.)	$\frac{3}{32}$ in. (0.093 in.)
20 to 24 in., inclusive	$\frac{1}{32}$ in. (0.031 in.)	$\frac{1}{8}$ in. (0.125 in.)

(*c*) *Thickness.*—The minimum wall thickness at any point for welded and seamless pipe shall not be more than 12.5 per cent under the nominal wall thickness specified.

Lengths

14. Pipe lengths shall be in accordance with the following regular practice:

(*a*) The lengths required shall be specified in the order;

(*b*) No jointers are permitted unless otherwise specified.

WORKMANSHIP AND FINISH.

Ends

15. Unless otherwise specified, pipe shall be furnished with plain ends. All burrs at the ends of the pipe shall be removed.

Finish

16. (*a*) The finished pipe shall be reasonably straight and free from injurious defects, and shall have a workmanlike finish.

Depth of Injurious Defect

(*b*) When the depth of defect of either welded or seamless pipe encroaches on the minimum wall thickness (87.5 per cent of the nominal thickness), or is in excess of 12.5 per cent of the nominal wall thickness, such defects shall be considered injurious.

Machining or Grinding Defects

(*c*) Pipe showing moderate slivers may be machined or ground inside or outside to a depth which shall insure the removal of all included scale and slivers, providing the wall thickness is not reduced below the minimum wall thickness required in these specifications. Machining or grinding shall follow inspection of the pipe as rolled, and shall be followed by supplementary visual inspection.

Repair by Welding

(*d*) Repair of injurious defects shall be permitted only subject to the approval of the purchaser. Welding of injurious defects in no case shall be permitted when the depth of defect exceeds $33\frac{1}{3}$ per cent of the nominal pipe wall thickness or the length of repair of seamless pipe exceeds 25 per cent of the nominal diameter of the pipe. Defects shall be thoroughly chipped out before welding. Each length of repaired pipe shall be retested hydrostatically in accordance with Section 6.

Marking

17. Each length of pipe manufactured in accordance with these specifications shall be legibly marked, either by stenciling, stamping or rolling, with the manufacturer's private identifying mark, together with the symbols A 106-A (B or C, or no letter if lap-welded) and an additional S if pipe meets the supplementary requirements specified in Sections 20 to 22. The length and rated steam pressure of the pipe also shall be included. Marking shall be within 12 in. of one end of each length. On pipe sizes 4 in. and larger, the weight shall be given. On small diameter pipe which is bundled, the above information may be legibly stamped on a metal tag securely attached to each bundle. When pipe marked as specified in this section is rejected, the designation A 106 shall be canceled.

INSPECTION AND REJECTION

Inspection

18. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the pipe ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the pipe is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment and at the manufacturer's expense, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection

19. Each length of pipe which develops injurious defects in shop working or application shall be rejected, and the manufacturer shall be notified. No rejections, under these or any other specifications, shall be marked as specified in Section 17 for sale under these specifications except where such pipe fails to comply with the weight requirements alone, in which case it may be sold under the weight specifications with which it does comply.

SUPPLEMENTARY REQUIREMENTS FOR SEAMLESS PIPE FOR USE IN CENTRAL STATIONS AT PRESSURES OF 400 LB. PER SQ. IN., OR OVER, AND TEMPERATURES OF 750 F., OR OTHER APPLICATIONS WHERE A SUPERIOR GRADE OF PIPE IS REQUIRED

20. The requirements in Sections 21 and 22, in addition to those previously specified, apply to seamless pipe 8 in. and over in nominal diameter for use in central stations at pressures of 400 lb. per sq. in. or over and temperatures up to 750 F., or other applications where a superior grade of pipe is required. *These requirements shall not be considered unless specified in the order*, in which event all tests shall be made at the mill at the purchaser's expense and witnessed by his inspector before shipment of the material. If these tests are required for smaller size seamless pipe, they shall be made the subject of agreement between the manufacturer and the purchaser.

Check Analysis

21. (*a*) Check analysis may be made on any length of pipe. Individual lengths failing to meet the chemical requirements specified in Section 3 shall be rejected.

Transverse Tension Tests

(*b*) Transverse tension tests may be made on specimens from both ends of each length of pipe. If the specimen from either end of any length fails to meet the physical properties specified in Sections 5 and 9, that length shall be rejected.

Flattening Tests

(*c*) The flattening tests specified in Section 7 (*b*) and (*c*) may be made on specimens from both ends of each length of pipe. Crop ends may be used. If the specimen from either end of any length fails to meet the specified requirements, that length shall be rejected.

Finish and Metal Structure

(*d*) The finished pipe shall be free from all immoderate slivers and depressions. The steel shall have a homogeneous structure as shown by the etching test in Paragraph (*e*).

Etching Tests

(*e*) Etching tests[1] may be made on sections from any pipe, and shall show sound and reasonably uniform material, free from injurious laminations, cracks and similar objectionable defects. Sections used for the flattening tests described in Section 7 (*b*) and (*c*) may be used for the etching test. If the specimen from any length shows objectionable defects, that length may be rejected.

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[1] Pending development of etching methods applicable to the product covered by these specifications, it is recommended that the Tentative Recommended Practice for a Standard Macro-Etch Test for Steel, described in the *National Metals Handbook*, Am. Soc. Steel Treating, 1930 edition, p. 415, be followed.

Rejection

22. At the purchaser's discretion, if 10 per cent of the pipe in any one lot fail to meet the requirements of Section 21, the entire lot may be rejected. Rejection of a lot shall be based on tests from not less than two pipes. A lot shall consist of all the pipe of the same size and wall thickness from any one heat bought by a purchaser.

EXPLANATORY NOTES

NOTE 1.—This contemplates temperatures from 500 to 850 F. Allowable pressures and their corresponding allowable temperatures are given in the following table. Higher temperatures with appropriate pressures may be used at the discretion of the designing engineer.

TABLE II.—ADJUSTED SERVICE PRESSURES[a] FOR POWER PIPING AT TEMPERATURES BELOW AND ABOVE 750 F.

STEAM SERVICE PRESSURE RATING AT 750 F., LB. PER SQ. IN.	250	300	400	600	900	1500
SERVICE TEMPERATURE, DEG. FAHR.	ADJUSTED SERVICE PRESSURES, LB. PER SQ. IN.					
500	310	370	500	720	1080	1800
550	300	360	480	720	1080	1800
600	290	350	460	700	1040	1740
650	280	330	440	670	1000	1660
700	260	315	420	630	950	1580
750	250	300	400	600	900	1500
800	200	250	325	500	750	1250
850	165	200	270	400	600	1000

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[a] These ratings apply to Table I, Dimensions and Weights of Lap-Welded and Grade-A-Seamless Steel Pipe for High-Temperature Service.

NOTE 2.—Grade A rather than Grades B or C seamless pipe should be used for close coiling, cold bending or for forge welding. The purpose for which pipe is to be used should be stated on the face of the order.

NOTE 3.—Table I is the recommendation of the Sectional Committee on Standardization of Dimensions and Material of Wrought-Iron and Wrought-Steel Pipe and Tubing, functioning under the procedure of the American Standards Association, A.S.A. Project No.: B36.

TENTATIVE SPECIFICATIONS

FOR

ZINC COATING (HOT-DIP) ON HARDWARE AND FASTENINGS[1]

A.S.T.M. Designation: A 153 – 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1933.

Scope

1. These specifications cover zinc coatings applied by the hot-dip process on hardware and fastenings, such as builders' hardware, pole line hardware, hardware for farm implements, bolts, nuts, screws, nails, rivets, awning pulleys and fittings, and other miscellaneous general hardware. These specifications are not intended to apply to coatings on marine hardware or on articles formed after coating.

MANUFACTURE

Slab Zinc

2. The zinc that goes into the galvanizing tank shall be any grade of zinc conforming to the requirements of the Standard Specifications for Slab Zinc (Spelter) (A.S.T.M. Designation: B 6) of the American Society for Testing Materials.[2]

WEIGHT OF COATING

Weight of Coating

3. The weight of zinc coating shall conform to the requirements shown in Table I for the class of material in which the article belongs. To determine the weight of coating an appropriate number of representative specimens, in no case less than three, or representative sections thereof, shall be used.

Weight of Coating Test

4. When material is inspected during manufacture the weight of coating may be determined by weighing the representative specimens after pickling and drying, and again after the coating is applied.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. A. B. Campbell, Secretary of the Sectional Committee on Specifications for Zinc Coating of Iron and Steel, Edison Electric Inst., 420 Lexington Ave., New York City.

[2] 1933 Book of A.S.T.M. Standards, Part I, p. 858.

5. If the material is inspected after the zinc coating is applied, the weight of the coating shall be determined by stripping the entire piece or suitable representative section thereof, in accordance with the hydrochloric acid - antimony chloride method as described in the Standard Methods of Determining Weight and Uniformity of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles (A.S.T.M. Designation: A 90) of the American Society for Testing Materials.[1]

UNIFORMITY OF COATING

Uniformity of Coating

6. The zinc coating shall be continuous and reasonably uniform in thickness. The coating on all classes of hardware shall withstand not less than four 1-minute dips when subjected to the Preece test, as described in the appendix to the Standard Methods of Determining Weight and Uniformity of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles (A.S.T.M. Designation: A 90) of the American Society for Testing Materials.[2] In employing the Preece test to determine the uniformity of coating an appropriate number of representative specimens, in no case less than three, or representative sections thereof, shall be used. In determining the uniformity of coating, threaded as well as plain portions of the specimens shall be included in the test.

TABLE I.—WEIGHT OF COATING FOR VARIOUS CLASSES OF MATERIAL.[a]

CLASS OF MATERIAL	MINIMUM WEIGHT OF ZINC COATINGS, OZ. PER SQ. FT. OF SURFACE	
	AVERAGE[b]	ANY INDIVIDUAL SPECIMEN
A. Castings—Gray Iron, Malleable Iron, Steel..........	1.80	1.60
B. Rolled, Pressed and Forged Articles (except those that would be included under the classifications *C* and *D* below)............................	2.00	1.85
C. Bolts and Drive Screws (⅜ in. in diameter and larger) and similar articles[b]..................	1.25	1.15
D. Screws, Stove Bolts, and Bolts (under ⅜ in. in diameter), Rivets, Nails and similar articles[c]....	0.90	0.80

[a] The technical committee responsible for these specifications proposes to investigate further the desirability of including requirements for heavier coating on small articles associated with or employed in assembling large members normally carrying coatings heavier than those specified in the above table.

[b] Number of specimens tested shall be at least three. See Section 3.

[c] In the case of threaded articles, such as bolts and screws, the determination of weight of coating shall be made on a portion of the article that does not include any threads.

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[1] 1933 Book of A.S.T.M. Standards, Part I, p. 317.

[2] *Ibid.*, p. 323.

PHYSICAL PROPERTIES AND TESTS

Adherence

7. The zinc coating shall adhere tenaciously to the surface of the base metal. When the coating is cut or pried into, such as with a stout knife applied with considerable pressure in a manner tending to remove a portion of the coating, it shall only be possible to remove small particles of the coating by paring or whittling, and it shall not be possible to peel any portion of the coating so as to expose the iron or steel.

WORKMANSHIP AND FINISH

Defects

8. The zinc-coated articles shall be free from uncoated spots. The coating shall be free from blisters, flux, black spots, dross, sharp projections or other defects not consistent with good commercial practice.

Threaded Articles

9. The zinc coating on threads shall not be subjected to a cutting, rolling or finishing tool operation, unless specifically authorized by the purchaser.

PACKING AND MARKING

Packing

10. The supplier shall employ such methods of packing zinc-coated articles as may reasonably be required to insure their receipt by the purchaser in satisfactory condition, the use to be made of the article being taken into consideration.

Marking

11. Where zinc-coated articles are packed in boxes, barrels, bags or wrappings, the containers shall be appropriately marked to indicate the contents and quantity.

INSPECTION, SAMPLING AND REJECTION

Inspection

12. The inspector representing the purchaser shall have free entry at all times to all parts of the manufacturer's works which concern the application of the zinc coating to the material ordered while work is being performed on material for the purchaser. The manufacturer shall afford the inspector, without charge, adequate facilities to determine whether the zinc coating is being furnished in accordance with these specifications. Unless otherwise mutually agreed upon between the purchaser and supplier, all inspection and tests shall be made at

the place of manufacture prior to shipment and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection

13. If any set of test specimens fails to conform to the requirements of these specifications for weight or uniformity of coating, two additional sets shall be tested, both of which shall conform to the requirements in every respect, or the lot of the material represented by the specimens may be rejected. Where failure to meet the requirements of the Preece test is due solely to nicks in the coating, accidentally resulting from handling, such failure shall be disregarded.

Additional Requirements

14. Complete detailed instructions will be given the supplier by the purchaser in all cases where modifications are to be made in these specifications to include additional requirements, such as heavier weights of coating, flexibility of coating to permit forming operations, degree of smoothness, appearance, such as brightness or spangles, special packing, special marking, etc.

TENTATIVE SPECIFICATIONS
FOR
WROUGHT-IRON RIVETS AND RIVET ROUNDS[1]

A.S.T.M. Designation: A 152 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1933.

A. Requirements for Rolled Bars

MANUFACTURE

Process

1. The rivet bars shall be made from wrought iron[2] which shall be free from any admixture of iron scrap or steel.

NOTE.—The term iron scrap applies only to foreign or bought scrap and does not include local mill products which are free from foreign or bought scrap. Any local mill products used shall be the equal or of a higher grade than the material specified.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition

2. The wrought iron shall conform to the following requirement as to chemical composition:

Manganese, max., per cent.................................. 0.05

Check Analyses

3. (*a*) Analyses may be made by the purchaser from a broken test specimen representing each lot, as specified in Section 7 (*a*). At the discretion of the purchaser, the chemical analysis may be made from a rivet. Each rivet so tested shall not represent more than 2000 lb. of any one size.

(*b*) Drillings for analysis shall be so taken as to represent the entire cross-section of the specimen.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-2 on Wrought Iron, Reading Iron Co., 401 N. Broad St., Philadelphia, Pa.

[2] Wrought iron is defined as follows in the Standard Definitions of Terms Relating to Wrought Iron Specifications (A.S.T.M. Designation: A 81) of the American Society for Testing Materials:

Wrought Iron.—A ferrous material, aggregated from a solidifying mass of pasty particles of highly refined metallic iron, with which, without subsequent fusion, is incorporated a minutely and uniformly distributed quantity of slag.

PHYSICAL PROPERTIES AND TESTS

Tension Tests

4. (*a*) The wrought iron shall conform to the following minimum requirements as to tensile properties:

Tensile strength, lb. per sq. in.		47 000
Yield point, lb. per sq. in		0.6 tens. str.
Elongation[a] in 8 in., per cent	rounds ½ to ¾ in., incl., in diam.	24
	rounds over ¾ to 2 in., incl., in diam.	28

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[a] See Paragraph (*b*).

(*b*) Rounds under ½ in. in diameter will not be required to meet an elongation requirement.

(*c*) The yield point shall be determined by the drop of the beam or halt in the gage of the testing machine.

Bend Tests

5. (*a*) *Quenched, Cold-bend Tests.*—A test specimen shall be heated between 1600 and 1700 F. (870 and 925 C.), and quenched in cold water, after which it shall stand being bent cold through 90 deg. on a radius which is equal to the diameter of the specimen without fracture on the outside of the bent portion.

(*b*) *Nick-bend Tests.*—A test specimen, when nicked 25 per cent around the circumference with a tool having a 60-deg. cutting edge, to a depth of not less than 8 nor more than 16 per cent of the diameter or thickness of the specimen, and broken slowly, shall show a wholly fibrous fracture.

(*c*) *Hot-bend Tests.*—A test specimen, when heated to a temperature between 1700 and 1800 F. (925 and 980 C.), shall stand being bent through 180 deg. flat on itself without fracture on the outside of the bent portion.

(*d*) Bend tests may be made by pressure or blows.

Test Specimens

6. All test specimens shall be of the full section of the material as rolled.

Number of Tests

7. (*a*) All bars of a given size shall be piled separately, sorted in lots of 100 each. Two bars shall be selected at random from each lot or fraction thereof and tested as specified in Sections 4 to 6.

(*b*) If any of the specimens originally selected to represent a lot of material contains surface defects not visible before testing but visible after testing, or if a tension test specimen breaks outside the middle third of the gage length, as indicated by scribe scratches marked on the specimen before testing, the individual bar shall be rejected and one retest from a different bar shall be allowed.

Micrographic Examination

8. In case of doubt as to the presence of steel, the purchaser may, at his own expense, make micrographic examination to assist in determining whether the material conforms to the requirements of Section 1.

Permissible Variations

9. The diameter of rivet bars shall not vary from that specified by more than the amount given in the following table:

DIAMETER, IN.	PERMISSIBLE VARIATIONS IN DIAMETER, IN.	OUT OF ROUND, IN.
Up to ½, inclusive	±0.007	0.010
Over ½ to 1, inclusive	±0.010	0.013
Over 1 to 1¼, inclusive	±0.012	0.016
Over 1¼ to 1½, inclusive	±0.015	0.021
Over 1½ to 2, inclusive	±0.022	0.023

Finish

10. The bars shall be smoothly rolled and shall be free from slivers, depressions, crop ends and seams, and shall show no evidence of being burnt.

INSPECTION AND REJECTION

Inspection

11. (*a*) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the bars are being furnished in accordance with these specifications. Tests and inspection at the place of manufacture shall be made prior to shipment.

(*b*) The purchaser may make the tests to govern the acceptance or rejection of material in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

(*c*) All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection

12. (*a*) All bars of one size in any one lot will be rejected if the test specimens representing that size and lot do not conform to the requirements specified.

(*b*) Unless otherwise specified, any rejection based on tests made in accordance with Section 11 (*b*) shall be reported within five working days from the receipt of samples.

Rehearing

13. Samples tested in accordance with Section 11 (*b*), which represent rejected material, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

B. Requirements for Finished Rivets

Material

14. The material used in the manufacture of the rivets shall conform to the requirements for rolled bars as specified in Sections 1 to 13, inclusive.

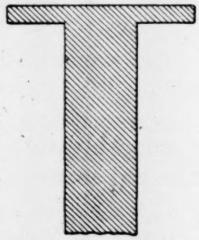

FIG. 1.—Flattening Test.

PHYSICAL PROPERTIES AND TESTS

Flattening Test

15. The rivet head shall stand being flattened, while hot, to a diameter two times the diameter of the shank, as shown in Fig. 1, without cracking at the edges.

Etch Test

16. The rivet shall be split longitudinally through head and shank. After grinding or polishing and etching in acid,[1] the section shall show freedom of folds at base of head, and the fiber lines shall show symmetrical displacement. (See Fig. 2).

Number of Tests

17. Three flattening and three etch tests shall be made from

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[1] A solution of 10 per cent hydrochloric acid (sp. gr. 1.19), 30 per cent sulfuric acid (sp. gr. 1.84), and 60 per cent water; or 25 per cent nitric acid (sp. gr. 1.42) and 75 per cent water, is recommended for the etch test.

each lot of 2000 lb. or less of any one diameter of rivets offered for inspection, each of which shall conform to the requirements specified in Sections 15 and 16.

WORKMANSHIP AND FINISH

Workmanship and Finish

18. The rivets shall be true to form and concentric, shall be made in a workmanlike manner, and shall be free from injurious defects. The heads shall not show cracks or splits on the edge but may contain a slight flash.

INSPECTION AND REJECTION

Inspection

19. The inspector representing the purchaser shall have free entry, at all times while the work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the rivets ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the rivets are being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture of the rivets prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

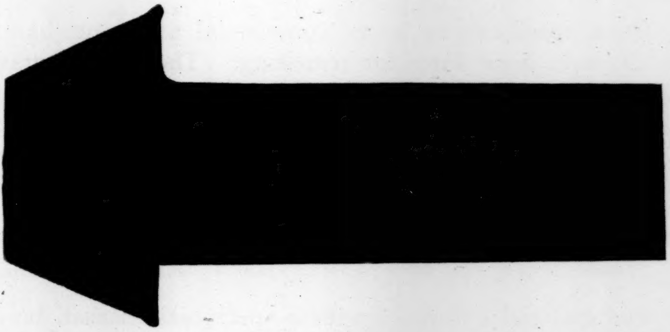

FIG. 2.—Showing Symmetrical Displacement of Fiber Lines After Etching Test.

Rejection

20. Rivets which show defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

TENTATIVE SPECIFICATIONS
FOR
ALUMINUM-BASE SAND-CASTING ALLOYS IN INGOT FORM[1]

A.S.T.M. Designation: B 58 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED AS TENTATIVE, 1926; ADOPTED IN AMENDED FORM, 1931;
REISSUED AS TENTATIVE, 1933.[2]

Scope

1. These specifications cover commercial aluminum-base sand-casting alloys in ingot form for remelting. The specific gravity of these alloys does not exceed 3.0. Nine alloys are specified and are designated Alloys B, C, E, F, G, GG, H, J, and K (see Explanatory Note).

MANUFACTURE

Process

2. The alloys may be made by any approved process.

Quality

3. The material covered by these specifications shall be of uniform quality, and shall be free from dross, slag and other harmful contamination.

CHEMICAL COMPOSITION AND TESTS

Chemical Composition

4. The alloys shall conform to the requirements as to chemical composition specified in Table I.

Sampling

5. (*a*) The sample for chemical analysis may be taken either by

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. J. A. Gann, Secretary of Committee B-7 on Light Metals and Alloys, Cast and Wrought, The Dow Chemical Co., Midland, Mich.

By adoption of these specifications, the American Society for Testing Materials does not undertake to insure anyone utilizing such specifications against liability for infringement of any patent or assume any such liability, and such adoption does not constitute a recommendation of any patented or proprietary application that may be involved.

These specifications are in effect a revision of and replace the former Standard Specifications for Aluminum-Base Sand-Casting Alloys in Ingot Form (A.S.T.M. Designation: B 58 - 31) which standard was accordingly discontinued in 1933.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 16, 1933.

sawing, drilling or milling the ingot, and shall represent the average cross-section of the piece.

(*b*) The saw, drill, cutter or other tool used shall be thoroughly cleaned. No lubricant shall be used in the operation, and the sawings or metal chips shall be carefully treated with a magnet to remove any particles of iron introduced in taking the sample.

TABLE I.—CHEMICAL COMPOSITIONS OF ALUMINUM-BASE SAND-CASTING ALLOYS.

Alloy	Aluminum, per cent	Copper, per cent	Iron, per cent	Silicon, per cent	Magnesium, per cent	Manganese, maximum, per cent	Zinc, maximum, per cent	Other Impurities, such as Sn, Sb, Pb, and Ni, max., per cent	Remarks
B....	remainder	7 to 8.5	0.8 to 1.2	1 to 1.5	0.05 max.	0.3	0.2	0.3	
C....	87 min.	6 to 8	1.3 max.	1 to 3	0.05 max.	0.3	2.0	1.0	
E ...	remainder	11 to 13	1 max.	1 max.	0.05 max.	0.3	0.2	0.3	
F....	remainder	9.25 to 10.75	1.3 max.	...	0.15 to 0.35	0.3	0.2	0.3	Iron plus silicon not to exceed 1.8 per cent.
G...	remainder	4 to 5	0.8 max.	0.5 to 1.2	0.02 max.	0.3	0.2	0.2	Total of all constituents other than aluminum and copper not to exceed 2.5 per cent.
GG..	remainder	4.5	0.8 max.	0.5 to 1.2	0.3 max.	0.3	0.2	0.2	
H...	remainder	3.5 to 4.5	0.8 max.	0.7 max.	1.2 to 1.7	0.3	0.1	0.3	Nickel 1.8 to 2.3 per cent.
J....	remainder	0.3 max.	0.6 max.	4.5 to 6	0.05 max.	0.3	0.2	0.3	
K...	remainder	0.3 max.	0.6 max.	12 to 13	0.05 max.	0.5	0.2	0.3	

INSPECTION AND REJECTION

Inspection

6. (*a*) Inspection may be made at the manufacturer's works where the alloys are made, or at the point at which they are received, at the option of the purchaser.

(*b*) If the purchaser elects to have inspection made at the manufacturer's works, the inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection

7. Material which does not conform to the requirements of these specifications may be rejected, and if rejected shall be replaced by the manufacturer without charge to the purchaser. The full weight of the rejected material shall be returned to the manufacturer.

EXPLANATORY NOTE

NOTE.—Explanatory Notes pertaining to the alloys covered by these specifications when used in the form of sand castings are given in connection with the Tentative Specifications for Aluminum-Base Alloy Sand Castings (A.S.T.M. Designation: B 26 – 33 T) of the American Society for Testing Materials.[1]

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[1] See p. 595.

TENTATIVE SPECIFICATIONS
FOR
ALUMINUM-BASE ALLOY SAND CASTINGS[1]

A.S.T.M. Designation: B 26 – 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED AS TENTATIVE, 1918; ADOPTED IN AMENDED FORM, 1921; REVISED, 1931; REISSUED AS TENTATIVE, 1933.[2]

Scope

1. These specifications cover commercial aluminum-base alloy sand castings having a specific gravity of 3 and less. Nine alloys are specified and are designated Alloys B, C, E, F, G, GG, H, J, and K (see Explanatory Notes).

MANUFACTURE

Process

2. The alloy may be made by any approved method.

CHEMICAL COMPOSITION AND TESTS

Chemical Composition

3. The alloys shall conform to the requirements as to chemical composition specified in Table I (see Explanatory Notes).

Sampling

4. (*a*) The sample for chemical analysis may be taken either by sawing, drilling or milling the casting or tension test specimen and shall represent the average cross-section of the piece.

(*b*) The saw, drill, cutter or other tool used shall be thoroughly cleaned. No lubricant shall be used in the operation, and the sawings or metal chips shall be carefully treated with a magnet to remove any particles of iron introduced in taking the sample.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. J. A. Gann, Secretary of Committee B-7 on Light Metals and Alloys, Cast and Wrought, The Dow Chemical Co., Midland, Mich.

By adoption of these specifications, the American Society for Testing Materials does not undertake to insure any one utilizing such specifications against liability for infringement of any patent or assume any such liability, and such adoption does not constitute a recommendation of any patented or proprietary application that may be involved.

These specifications are in effect a revision of and replace the former Standard Specifications for Aluminum-Base Alloy Sand Castings (A.S.T.M. Designation: B 26 – 31) which standard was accordingly discontinued in 1933.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 16, 1933.

PHYSICAL PROPERTIES AND TESTS

Tension Tests

5. The alloys shall conform to the minimum requirements as to tensile properties specified in Table II.

TABLE I.—CHEMICAL COMPOSITIONS OF ALUMINUM-BASE ALLOY SAND CASTINGS.

Alloy	Aluminum, per cent	Copper, per cent	Iron, per cent	Silicon, per cent	Magnesium, per cent	Manganese, maximum, per cent	Zinc, maximum, per cent	Other Impurities Such as Sn, Sb, Pb, and Ni, max., per cent	Remarks
B....	remainder	7 to 8.5	0.8 to 1.4	1 to 1.5	0.05 max.	0.3	0.2	0.3	
C....	86.5 min.	6 to 8	1.5 max.	1 to 3	0.05 max.	0.3	2.2	1.0	
E....	remainder	11 to 13	1.2 max.	1 max.	0.05 max.	0.3	0.2	0.3	
F....	remainder	9.25 to 10.75	1.5 max.	...	0.15 to 0.35	0.3	0.2	0.3	Iron plus silicon not to exceed 2 per cent.
G...	remainder	4 to 5	1.2 max.	1.2 max.	0.02 max.	0.3	0.2	0.2	Total of all constituents other than aluminum and copper not to exceed 2.5 per cent.
GG..	remainder	4.5	1.2 max.	1.2 max.	0.3 max.	0.3	0.2	0.2	
H...	remainder	3.5 to 4.5	1 max.	0.7 max.	1.2 to 1.7	0.3	0.1	0.3	Nickel 1.8 to 2.3 per cent.
J....	remainder	0.4 max.	0.8 max.	4.5 to 6	0.05 max.	0.3	0.2	0.3	
K...	remainder	0.3 max.	0.8 max.	12 to 13	0.05 max.	0.5	0.2	0.3	

TABLE II.—TENSILE PROPERTIES OF ALUMINUM-BASE ALLOY SAND CASTINGS.

ALLOY		TENSILE STRENGTH, MINIMUM, LB. PER SQ. IN.	ELONGATION IN 2 IN., MINIMUM, PER CENT
B		19 000	....
C		19 000	....
E		19 000	....
F		19 000	....
G	Heat Treatment No. 1[a]	28 000	6
	Heat Treatment No. 2[a]	30 000	3
	Heat Treatment No. 3[a]	36 000	....
GG	Heat Treated[b]	36 000	....
H	Heat Treated[c]	32 000	....
J		17 000	3
K		24 000	5

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[a] See Explanatory Notes, Alloy G.

[b] See Explanatory Notes, Alloy GG.

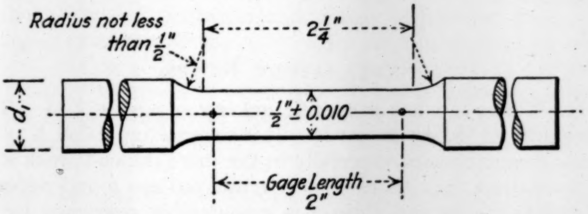
[c] See Explanatory Notes, Alloy H.

Test Specimens

6. The test bars shall be separately cast in green sand and shall be "cast to size" according to the dimensions shown in Fig. 1. If the castings are heat treated, the test bars representing such castings shall be similarly heat treated. They shall not be machined prior to test except to adapt the grips to the holders of the testing machine in such a manner as to insure an axial load.

Number of Tests

7. (*a*) The tests shall, so far as possible, be made by heats or melts but, unless otherwise agreed upon, two tension tests shall be made for each unit of 500 lb. or fraction thereof.



NOTE:

The Gage Length, Parallel Section and Fillets shall be as shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a way, that the Load shall be Axial.

In Order to promote the Breaking of the Specimen in the Center it is permissible to use a Taper in the Reduced Section from the Fillets to the Center of not to exceed 0.010 in.

It is recommended, that Diameter d_1 be from 3/4" to 1."

FIG. 1.—Tension Test Specimen.

(*b*) If any test specimen shows defective machining or develops flaws, it may be discarded; in which case the manufacturer and the purchaser or his representative shall agree upon the selection of another specimen in its stead.

INSPECTION AND REJECTION

Inspection

8. (*a*) Inspection may be made at the manufacturer's works where the castings are made, or at the point at which they are received, at the option of the purchaser.

(*b*) If the purchaser elects to have inspection made at the manufacturer's works, the inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is

being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection

9. Castings which show injurious defects revealed by machining operations subsequent to acceptance may be rejected, and if rejected shall be replaced by the manufacturer without charge to the purchaser. The full weight of the original material rejected shall be returned to the manufacturer.

EXPLANATORY NOTES

Alloy B.—This alloy has a specific gravity of about 2.83. The pattern shrinkage is about 0.156 ($\frac{5}{32}$) in. per ft. It is superseding Alloy A as it possesses better casting characteristics, especially in the more difficult work where higher pouring temperatures than those usually employed are found necessary. The tendency towards cracks and shrinks is considerably overcome by the careful control of the iron and silicon contents. This alloy is used for general casting purposes.

Alloy C.—The specific gravity of this alloy is about 2.83 to 2.86. The pattern shrinkage is about 0.156 ($\frac{5}{32}$) in. per ft. It has somewhat better machining qualities than Alloy B. It is used for about the same purposes as Alloy B, particularly for automotive work, such as crank and transmission cases and similar parts.

Alloy E.—This alloy has a specific gravity of about 2.95 and the pattern shrinkage is 0.156 ($\frac{5}{32}$) in. per ft. It is used for pumps, manifolds, and general castings which should be leak proof. The high copper content makes the alloy more brittle and lowers its shock resistance.

Alloy F.—The specific gravity of this alloy is about 2.90 and the pattern shrinkage about 0.156 ($\frac{5}{32}$) in. per ft. The alloy is used for pistons, cylinder heads, valve guides, and bearings or other parts where hardness and good bearing qualities are essential. Together with Alloy H it possesses the property of retaining at higher temperatures a greater percentage of its room temperature strength than any other alloy in this group. This alloy may be heat treated, in which case substantially higher strength and hardness or other desirable characteristics are obtained.

Alloy G.—This alloy has a specific gravity of about 2.78. It is for general casting purposes where a combination of lightness, higher strength and ductility is desired. The various strengths are obtained through different heat treatments. Heat Treatment No. 1 gives maximum elongation and resistance to shock. It is a solution heat treatment and may be specified where the most rugged service is required. An aging effect takes place on standing which increases the strength and slightly decreases the elongation. Heat Treatment No. 2 is a solution and precipitation heat treatment, and should be specified where a higher initial strength, yield point and hardness are desired. Heat Treatment No. 3 should be specified where the highest strength and hardness are desired and lower ductility is not objectionable. This alloy with the various heat treatments is used in general for high strength parts in street cars and busses, parts for internal combustion engines, outboard motor parts and other marine castings.

Alloy GG.—This alloy is used in the heat-treated condition where high strength and maximum hardness are desired, such as bearing caps.

Alloy H.—The specific gravity of this alloy is about 2.80. It is usually employed in the heat-treated condition. The alloy is used for pistons, cylinder heads, valve guides and bearings or other parts where hardness or good bearing qualities are essential. Together with Alloy F it possesses the property of retaining at higher temperatures a greater percentage of its room-temperature strength than any other alloy in this group.

Alloy J.—This alloy is somewhat lighter than aluminum, having a specific gravity of about 2.69. It withstands corrosion better than the copper alloys. The free flowing property of the alloy when molten makes it easier to pour castings of thin section or intricate design. Its leak proof properties are valuable where pressure tightness is essential. It has a lower strength and yield point than the copper alloys and poorer machining qualities. It is especially suitable for automobile body parts, cooking utensils, architectural and marine castings

Alloy K.—The specific gravity of this alloy is about 2.68. Immediately before pouring, the alloy is treated by a process called "modification." Its corrosion resistance is good, especially to salt water. It has good foundry characteristics and can be used for castings having both thin and heavy sections. It is not as readily machined and has a lower yield point in proportion to tensile strength than most of the copper alloys. It is used for marine castings, bus, street car and engine parts, and for thin castings such as radiators, small motor housings and meter cases.

TENTATIVE SPECIFICATIONS

FOR

ALUMINUM-ALLOY (DURALUMIN) BARS, RODS AND SHAPES (ALUMINUM-COPPER-MAGNESIUM-MANGANESE)[1]

A.S.T.M. Designation: B 89 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932; REVISED, 1933.[2]

MANUFACTURE

Manufacture.

1. No scrap shall be used in the manufacture of the material except such as may accumulate in the manufacturer's own plants from material of similar composition and of his own manufacture.

CHEMICAL COMPOSITION AND TESTS

Chemical Composition.

2. The composition of the material as determined by chemical analysis shall conform to the following requirements:

Aluminum, minimum, per cent	92.0
Copper, per cent	3.5 to 4.5
Magnesium, per cent	0.2 to 0.75
Manganese, per cent	0.4 to 1.0

Chemical Analysis.

3. Samples for chemical analysis shall be taken from a random piece representing each lot of 2000 lb. or fraction thereof, or such other quantity as may be mutually agreed upon between the manufacturer and purchaser. Samples may be taken from tension or bend test specimens. The sample for analysis may be prepared by shearing or by drilling or machining without the use of any lubricant in such a manner as to give a sample representative of the entire cross-

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. J. A. Gann, Secretary of Committee B-7 on Light Metals and Alloys, Cast and Wrought, The Dow Chemical Co., Midland, Mich.

By adoption of these specifications, the American Society for Testing Materials does not undertake to insure anyone utilizing such specifications against liability for infringement of any patent or assume any such liability, and such adoption does not constitute a recommendation of any patented or proprietary application that may be involved.

[2] Revision accepted by Committee E-10 on Standards, August 16, 1933.

section of the material. Samples so prepared shall be divided into three equal parts, each of which shall be placed in a sealed package, one for the manufacturer, one for the purchaser, and one for an umpire if necessary.

PHYSICAL PROPERTIES AND TESTS

Temper and Tensile Strength. 4. The material shall be supplied in the temper specified in the contract or purchase order and shall conform to the requirements as to tensile properties for the specified temper as shown in Table I.

TABLE I.—MECHANICAL PROPERTIES OF BARS, RODS AND SHAPES.

SECTION	DIAMETER OR LEAST DISTANCE ACROSS FLATS	TENSILE STRENGTH, LB. PER SQ. IN.	YIELD STRENGTH, MINIMUM, LB. PER SQ. IN.[a]	ELONGATION, MINIMUM, PER CENT[b]
		ANNEALED		
All sections.....	Up to 0.125 in., inclusive.........	35 000 max.	.....	..
	0.126 to 10.0 in....	35 000 max.	.....	16
		HEAT TREATED		
Rounds, Squares, Hexagons and Octagons	Up to 0.125 in......	55 000 min.	30 000	..
	0.126 to 0.750 in...	55 000 min.	30 000	18
	0.751 to 3.000 in...	53 000 min.	30 000	18
	3.001 to 8.000 in...	50 000 min.	28 000	16
Rectangles......	Up to 0.750 in. thickness.........	53 000 min.	30 000	16
	0.751 to 3.000 in. thickness.........	50 000 min.	28 000	16
Structural shapes[c].......	....	50 000 min.	30 000	16
Extruded sections	....	50 000 min.	30 000	16

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[a] Yield strength is defined as the stress which produces a permanent set of 0.2 per cent of the initial gage length.

[b] The gage length for measurement of elongation shall be equal to four times the diameter or distance across flats except in sections for which a flat tension test specimen is used in which case the gage length shall be 2 in.

[c] Sizes as follows: Angles and Z-bars up to 6 by 6 in.; channels up to 10 in.; I-beams and H-beams up to 5 in. sizes in standard web or leg thicknesses.

Bend Test. 5. Bend test specimens shall stand being bent through an angle of 180 deg. around a diameter equal to four times the thickness of the specimen without cracking.

Test Specimens. 6. (*a*) Test coupons shall be selected at random to represent each lot of 2000 lb. or fraction thereof, or such other quantity as may be mutually agreed upon between the manufacturer and purchaser.

(*b*) The tension test specimen may be a full section of the material, or the standard 0.505-in. tension test specimens, Fig. 1, machined from the test coupon may be used. In the case of thin material the specimen may have the form and dimensions of the standard sheet tension test specimen having a width of ½ in. and a reduced section of 2¼ in. as shown in Fig. 2.

(*c*) The bend test specimen may be (*1*) a full section of the material or (*2*) a ¾-in. round specimen machined from the material or (*3*) a rectangular specimen approximately 1 in. in width and having the thickness of the section from which it is taken, or a ratio of width to thickness not less than six to one. The edges of the rectangular specimen may be rounded to a radius of approximately one-half the thickness.

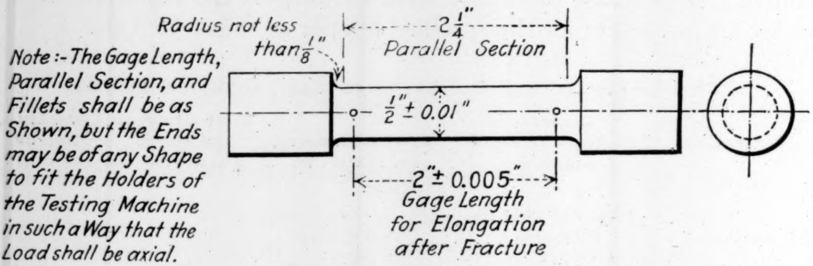
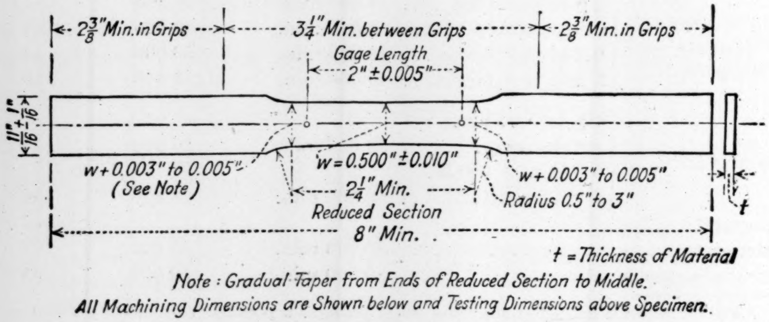

Radius not less than 1/8"
2 1/4"
Parallel Section
Note:- The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.
1/2" ± 0.01"
2" ± 0.005"
Gage Length for Elongation after Fracture

FIG. 1.—Standard 2-in. Gage Length Tension Test Specimen.


2 3/8" Min. in Grips
3 1/4" Min. between Grips
2 3/8" Min. in Grips
Gage Length
2" ± 0.005"
11/16" ± 1/16"
w + 0.003" to 0.005" (See Note)
w = 0.500" ± 0.010"
w + 0.003" to 0.005"
2 1/4" Min.
Reduced Section
Radius 0.5" to 3"
8" Min.
t
t = Thickness of Material
Note: Gradual Taper from Ends of Reduced Section to Middle.
All Machining Dimensions are Shown below and Testing Dimensions above Specimen.

The ends shall be symmetrical within 0.01 in.

FIG. 2.—Standard Tension Test Specimen for Sheet Metals.

(*d*) For material up to 1½ in. in diameter or thickness, the tension and bend test specimens shall be machined from the center of the section; for material 1½ in. and over, specimens shall be machined from the material midway between the center and the outside of the section. Specimens shall be taken parallel to the direction of rolling or extrusion.

PERMISSIBLE VARIATIONS IN DIMENSIONS

Permissible Variations. 7. Variations from the specified dimensions for the class of material ordered shall not exceed the amounts shown in Tables II and III.

WORKMANSHIP AND FINISH

Workmanship and Finish. 8. The material shall be of uniform quality and temper, clean, sound, smooth, commercially straight or flat and free from pipes, laps, cracks, twists, seams, damaged ends and other injurious defects.

TABLE II.—DIMENSIONS AND PERMISSIBLE VARIATIONS OF ALLOY BARS AND RODS.

COLD FINISHED ROUNDS, SQUARES, HEXAGONS AND OCTAGONS; ALSO RECTANGLES UP TO 2.75 IN. IN WIDTH, PROVIDED AREA IS NOT GREATER THAN 3 SQ. IN.

Diameter or Distance Across Flats, in.	Tolerance, in., plus or minus		
	Rounds	Squares, Hexagons, Octagons	Rectangles
Up to 0.064	0.001	0.0015	0.0015
0.065 to 0.500	0.0015	0.002	0.002
0.501 to 1.000	0.002	0.0025	0.0025
1.001 to 1.500	0.0025	0.003	0.003
1.501 to 2.75	......	......	0.005

ROLLED ROD

Diameter, in.	Tolerance, in.	
	Plus	Minus
0.375 to 1.500	0.015	0.015
1.501 to 3.499	0.008	0.008
3.500 to 5.000	$\frac{1}{32}$	$\frac{1}{64}$
5.001 to 8.000	$\frac{1}{16}$	$\frac{1}{32}$

ROLLED BAR (Including Squares, Hexagons, Octagons and Rectangles)

Least Distance Across Flats, in.	Tolerance, in., plus or minus
Up to 0.500	0.006
0.501 to 0.750	0.008
0.751 to 1.000	0.012
1.001 to 2.000	0.016
2.001 to 3.000	0.020
Width (of Rectangles), in.	
Up to 1.500	$\frac{1}{64}$
1.501 to 4.000	$\frac{1}{32}$
4.010 to 6.000	$\frac{3}{64}$
6.001 to 10.000	$\frac{1}{16}$

INSPECTION AND REJECTION

Inspection. 9. The manufacturer shall afford the purchaser, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications.

Rejection. 10. Material which fails to conform to these specifications will be rejected and the manufacturer shall be notified.

TABLE III.—DIMENSIONS AND PERMISSIBLE VARIATIONS OF ALLOY SHAPES.

STRUCTURAL SHAPES, ROLLED

	Tolerance on Section Thickness
Channels up to 10 in. Angles and Z-bars up to 6 by 6 in.	±2½ per cent of nominal thickness except that the tolerance shall not be less than ±0.010 in.
	Tolerance on Over-all Dimensions
Angles and Z-bars up to 6 by 6 in.	Lengths of leg: ±2½ per cent of nominal lengths, except that the minimum tolerance shall be ±$\frac{1}{16}$ in.
Channels up to 10 in.	Over-all width: +$\frac{3}{32}$ in. −$\frac{1}{16}$ in. Width of flange: ±4 per cent of nominal width
	Tolerance on Weight
Angles and Z-bars from 3 by 3 in. to 6 by 6 in.	±2½ per cent of the nominal weight for a lot or shipment.

SHAPES, EXTRUDED

Dimensions, in.	Tolerance, in., plus or minus
Up to 0.125, inclusive	0.010
0.126 to 0.500, inclusive	0.015
0.501 to 1.000, inclusive	0.020
1.001 to 2.000, inclusive	0.025
2.001 to 3.000, inclusive	0.030
3.001 to 4.000, inclusive	0.035
4.001 to 5.000, inclusive	0.045
5.001 and over	0.060

ROUNDS, SQUARES, RECTANGLES, HEXAGONS, OCTAGONS, BARS AND RODS, EXTRUDED

Dimensions, in.	Tolerance, in., plus or minus
Up to 0.500	0.007
0.501 to 1.000	0.010
1.001 to 2.000	0.012
2.001 to 3.000	0.015
3.001 and over	0.018

PERMISSIBLE VARIATIONS IN LENGTH

Length, ft.	Tolerance, in.
Up to 20	+$\frac{1}{4}$
Over 20 to 30	+$\frac{3}{8}$
Over 30 to 85	+$\frac{1}{2}$

TENTATIVE SPECIFICATIONS
FOR
ALUMINUM SHEET AND PLATE[1]

A.S.T.M. Designation: B 25 – 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED AS TENTATIVE, 1918; ADOPTED IN AMENDED FORM, 1929;
REISSUED AS TENTATIVE, 1933.[2]

Scope

1. These specifications cover aluminum sheet and plate. Commercial flat sheet shall be supplied on orders for sheet, except where coiled or strip sheet is specifically ordered.

Manufacture

2. No scrap shall be used in the manufacture of aluminum sheet and plate except such as shall accumulate at the manufacturer's plants from material of similar composition and of his own manufacture.

CHEMICAL COMPOSITION AND TESTS

Chemical Composition

3. The sheet and plate shall contain a minimum of 99 per cent aluminum as determined by chemical analysis.

Samples

4. Samples for analysis shall be taken from a random sheet to represent each 1000 lb. (453.6 kg.) of sheet, and from a random plate to represent each 2000 lb. (907.2 kg.) of plate, or such other quantity as may be mutually agreed upon between the manufacturer and the purchaser. Samples for analysis may be obtained from the tension or bend test specimens described in Section 7. The sample for analysis may be prepared by shearing or by drilling or machining without the use of any lubricant in such a manner as to give a sample representative of the entire cross-section of the sheet or plate. Samples so prepared shall be divided into three equal parts, each of which shall be placed in a sealed package, one for the manufacturer, one for the purchaser and one for an umpire if necessary.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. J. A. Gann, Secretary of Committee B-7 on Light Metals and Alloys, Cast and Wrought, The Dow Chemical Co., Midland, Mich.

These specifications are in effect a revision of and replace the former Standard Specifications for Aluminum Sheet (A.S.T.M. Designation: B 25 – 29) which were accordingly discontinued in 1933.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 16, 1933.

PHYSICAL PROPERTIES AND TESTS

Tensile Requirements

5. (*a*) Sheet shall be supplied in the temper specified in the contract or purchase order and shall conform to the following minimum requirements as to tensile properties for the specified temper and thickness:

TEMPER	THICKNESS, IN.	TENSILE STRENGTH, LB. PER SQ. IN.	ELONGATION IN 2 IN., MINIMUM, PER CENT
Soft	0.013 to 0.019	15 500 max.	15
	0.020 to 0.031	15 500 max.	20
	0.032 to 0.050	15 500 max.	25
	0.051 to 0.250	15 500 max.	30
Half Hard	0.013 to 0.019	16 000 min.	4[a]
	0.020 to 0.031	16 000 min.	5[a]
	0.032 to 0.050	16 000 min.	7[a]
	0.051 to 0.113	16 000 min.	9[a]
	0.114 to 0.250	16 000 min.	10
Three-quarter Hard	0.013 to 0.019	19 000 min.	1
	0.020 to 0.031	19 000 min.	2
	0.032 to 0.050	19 000 min.	3
	0.051 to 0.128	19 000 min.	4
Hard	0.013 to 0.019	22 000 min.	1
	0.020 to 0.031	22 000 min.	2
	0.032 to 0.050	22 000 min.	3
	0.051 to 0.128	22 000 min.	4

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[a] This value is required for flat sheet. For coiled sheet in the half-hard temper, the elongation may be less than that for flat sheet by 1 per cent in 2 in. The maximum thickness of coiled or strip sheet commercially available in the half-hard temper is 0.080 in.

(*b*) Unless otherwise specified, plate (thickness 0.250 in. and over) shall be supplied as rolled (see Explanatory Note 2) and tension tests shall not be required.

(*c*) If so specified, plate shall be supplied in the soft temper in thicknesses from 0.250 to 3.000 in., in which case the tensile strength shall not exceed 19,000 lb. per sq. in. and the elongation shall not be less than 25 per cent in 2 in.

Bend Tests

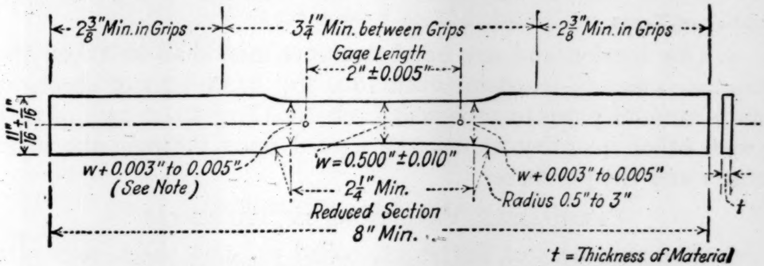
6. (*a*) Bend test specimens taken from sheet in the soft or in the half-hard temper or from plate in the soft temper or as rolled shall stand being bent cold through 180 deg. flat on themselves without cracking.

(*b*) Bend test specimens taken from sheet in the three-quarter-hard temper shall stand being bent cold through 180 deg. around a pin having a diameter equal to four times the thickness of the sheet without cracking.

(*c*) The bend test shall not be required for sheet in the hard temper.

Test Specimens

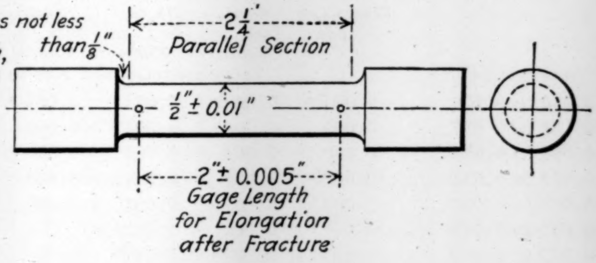
7. (*a*) *Tension Tests.*—Tension test specimens for sheet in the half-hard temper shall be taken parallel to the direction of rolling; for sheet in the soft, three-quarter-hard and hard tempers, the tension test specimens may be taken in any direction. (See Explanatory Notes 1 and 3.) For sheet and plate under 0.500 in. in thickness the standard sheet tension test specimen shown in Fig. 1 shall be used. For plate 0.500 in. or over in thickness, the standard 0.505-in. diameter round specimen shown in Fig. 2 or a similar round specimen having the maximum possible dimensions proportional to those of the standard 0.505-in. diameter specimen shall be used.


2⅜" Min. in Grips
3¼" Min. between Grips
2⅜" Min. in Grips
Gage Length
2" ± 0.005"
11/16" ± 1/16"
w + 0.003" to 0.005"
(See Note)
w = 0.500" ± 0.010"
2¼" Min.
Reduced Section
w + 0.003" to 0.005"
Radius 0.5" to 3"
8" Min.
t
t = Thickness of Material

Note: Gradual Taper from Ends of Reduced Section to Middle.
All Machining Dimensions are Shown below and Testing Dimensions above Specimen.

The ends shall be symmetrical within 0.01 in.

FIG. 1.—Standard Tension Test Specimen for Sheet Metals.


Radius not less than ⅛"
2¼"
Parallel Section
½" ± 0.01"
2" ± 0.005"
Gage Length for Elongation after Fracture

Note:- The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.

FIG. 2.—Standard 2-in. Gage Length Tension Test Specimen.

(*b*) *Bend Tests.*—Bend test specimens may be taken in any direction from sheet in the soft, half-hard or three-quarter-hard temper and from plate in the soft temper or as rolled. Bend test specimens from thin sheet and strip shall be of the full thickness, and in the case of strips 1 in. in width or under, of the full width of the material. The width of specimens from material over 1 in. in width shall be six times the thickness, but not less than 1 in. The edges may be rounded to a $\frac{1}{16}$-in. radius. When practicable the length shall be at least 6 in. For plates over 0.500 in. in thickness a machined bend test specimen 1 by ½ in. in cross-section and at least 6 in. in length shall be used. The edges may be rounded to a $\frac{1}{16}$-in. radius. When permitted by the inspector, the cross-section may be modified to ½ in. square. In the case of plate ¾ in. or over in thickness, a ¾-in. round specimen machined from the material may be used. From plate 1½ in. or over in thickness, the specimen shall be taken midway between the center and surface of the plate.

Number of Tests

8. One tension and one bend test specimen shall be taken from a random sheet to represent each 1000 lb. (453.6 kg.) of sheet, and from a random plate to represent each 2000 lb. (907.2 kg.) of plate, or such other quantity as may be agreed upon between the manufacturer and the purchaser.

PERMISSIBLE VARIATIONS IN THICKNESS

9. The thickness of flat sheet, coiled or strip sheet, and plate, shall not vary from that specified by more than the respective tolerances indicated in the following table:

FLAT SHEET

	18 in. in Width and Under	Over 18 to 36 in., Incl., in Width	Over 36 to 54 in., Incl., in Width	Over 56 to 72 in., Incl., in Width	Over 72 to 90 in., Incl., in Width	Over 90 to 102 in., Incl., in Width
Thickness, in.	Thickness tolerance, plus or minus, in.					
0.250 to 0.129	0.04T[a]	0.04T[a]	0.05T[a]	0.06T[a]	0.07T[a]	0.08T[a]
0.128 to 0.092	0.004	0.0045	0.005	0.007	0.009	0.010
0.091 to 0.073	0.003	0.003	0.004	0.006	0.008	......
0.072 to 0.051	0.0025	0.003	0.004	0.005	0.007	......
0.050 to 0.037	0.002	0.0025	0.003	0.004	......	......
0.036 to 0.018	0.0015	0.002	0.0025	......	......	......
0.017 to 0.010	0.0015	0.0015	0.002	......	......	......

COILED SHEET

	12 in. in Width and Under	Over 12 to 24 in., Incl., in Width	Over 24 in. in Width
Thickness, in.	Thickness tolerance, plus or minus, in.		
0.128 to 0.103	0.0035	0.0035	0.004
0.102 to 0.091	0.003	0.003	0.004
0.090 to 0.073	0.003	0.003	0.003
0.072 to 0.051	0.0025	0.003	0.003
0.050 to 0.041	0.0025	0.0025	0.0025
0.040 to 0.030	0.002	0.0025	0.0025
0.029 to 0.019	0.002	0.002	0.002
0.018 to 0.011	0.0015	0.002	......
0.010 to 0.008	0.001	0.0015	......
0.007 to 0.006	0.001	0.001	......

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[a] T = the nominal thickness.

PLATE

THICKNESS, IN.	54 IN. IN WIDTH AND UNDER	OVER 54 TO 72 IN., INCL., IN WIDTH	OVER 72 TO 90 IN., INCL., IN WIDTH	OVER 90 TO 120 IN., INCL., IN WIDTH
	THICKNESS TOLERANCE, PLUS OR MINUS, PER CENT OF NOMINAL THICKNESS			
3.000 to 1.001	3	3	4	5
1.000 to 0.501	4	4	5	6
0.500 to 0.251	5	5	6	7
0.250 to 0.125	5	6	7	8

WORKMANSHIP AND FINISH

Workmanship and Finish

10. All sheet and plate shall be commercially flat and free from buckles; they shall be free from injurious surface defects and shall have a workmanlike finish.

INSPECTION AND REJECTION

Inspection

11. The manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications.

Rejection

12. Materials which fail to conform to these specifications will be rejected and the manufacturer shall be notified.

EXPLANATORY NOTES

NOTE 1.—In the case of sheet in the half-hard temper, there is an appreciable difference in the elongation depending upon the direction in which the test specimen is taken from the sheet. This measurement made parallel to the direction of final rolling is distinctly higher than if the specimen were cut perpendicular to this direction. This difference is not observed in hard or soft sheet. The inspection of half-hard sheet calls for the use of specimens parallel to the direction of final rolling because of the greater contrast with the values obtained from hard sheet. The fact that the bend-test specimens may be taken without regard to the direction of rolling is evidence that the lower elongation across the grain does not indicate a lack of workability.

NOTE 2.—The mechanical properties of "as rolled" plate lie between those of the soft temper and those of the half-hard temper. Thinner plates (up to about 0.5 in.), because of the cooling during the rolling operation, have strengths which average around the minimum for half-hard temper. As the thickness increases the properties approach those of the soft temper. Where higher properties are required it is more economical to use a stronger aluminum alloy rather than to specify an intermediate temper (half-hard or quarter-hard) because of the cost of cold rolling heavy plates.

NOTE 3.—The use of grips which insure a uniform axial loading of the test specimen is essential, if satisfactory results are to be obtained.

TENTATIVE SPECIFICATIONS

FOR

ALUMINUM-ALLOY (DURALUMIN) SHEET AND PLATE (ALUMINUM-COPPER-MAGNESIUM-MANGANESE)[1]

A.S.T.M. Designation: B 78 – 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED AS TENTATIVE, 1930; ADOPTED, 1931; REISSUED AS TENTATIVE, 1933.[2]

Manufacture

1. No scrap shall be used in the manufacture of aluminum-alloy (duralumin) sheet and plate except such as shall accumulate at the manufacturer's plants from material of similar composition and of his own manufacture.

CHEMICAL COMPOSITION AND TESTS

Chemical Composition

2. The sheet or plate shall conform to the following requirements as to chemical composition:

Copper, per cent	3.5 to 4.5
Magnesium, per cent	0.2 to 0.75
Manganese, per cent	0.4 to 1.0
Aluminum, minimum, per cent	92

Chemical Analysis

3. Samples for analysis shall be taken from a random sheet to represent each 1000 lb. (453.6 kg.) of sheet, and from a random plate to represent each 2000 lb. (907.2 kg.) of plate, or such other quantity as may be mutually agreed upon between the manufacturer and the purchaser. Samples for analysis may be obtained from the tension or bend test specimens described in Section 6. The sample for analysis may be prepared by shearing or by drilling or by machining without

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. J. A. Gann, Secretary of Committee B-7 on Light Metals and Alloys, Cast and Wrought, The Dow Chemical Co., Midland, Mich.

By adoption of these specifications, the American Society for Testing Materials does not undertake to insure anyone utilizing such specifications against liability for infringement of any patent or assume any such liability, and such adoption does not constitute a recommendation of any patented or proprietary application that may be involved.

These specifications are in effect a revision of and replace the former Standard Specifications for Aluminum-Alloy (Duralumin) Sheet (A.S.T.M. Designation: B 78 – 31) which were accordingly discontinued in 1933.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 16, 1933.

the use of any lubricant in such a manner as to give a sample representative of the entire cross-section of the sheet or plate. Samples so prepared shall be divided into three equal parts, each of which shall be placed in a sealed package, one for the manufacturer, one for the purchaser and one for an umpire if necessary.

PHYSICAL PROPERTIES AND TESTS

Tensile Requirements

4. Sheet and plate shall be supplied in the temper specified in the contract or purchase order and shall conform to the following requirements as to tensile properties for the specified temper and thickness:

TEMPER	THICKNESS, IN.	TENSILE STRENGTH, LB. PER SQ. IN.	YIELD STRENGTH,[a] MINIMUM, LB. PER SQ. IN.	ELONGATION IN 2 IN., MINIMUM, PER CENT	BEND DIAMETER, FACTOR, "n"
Annealed......	0.010 to 0.032...	35 000 max.	......	12	0
	0.033 to 0.064...	35 000 max.	......	12	1
	0.065 to 0.128...	35 000 max.	......	12	2
	0.129 to 0.258...	35 000 max.	......	12	4
	0.259 to 0.500...	35 000 max.	......	12	6
Heat Treated..	0.010 to 0.020...	55 000 min.	32 000	15	3
	0.021 to 0.036...	55 000 min.	32 000	18[b]	3
	0.037 to 0.128...	55 000 min.	32 000	18[b]	4
	0.129 to 0.258...	55 000 min.	32 000	15	6
	0.259 to 0.500...	55 000 min.	32 000	12	8
	0.501 to 1.750...	55 000 min.	32 000	10	..
Rolled After Heat Treating.........	0.020 to 0.031...	55 000 min.	42 000	10	3
	0.032 to 0.036...	55 000 min.	42 000	11	3
	0.037 to 0.064...	55 000 min.	42 000	12	4
	0.065 to 0.128...	55 000 min.	42 000	12	5
	0.129 to 0.188...	55 000 min.	42 000	12	8

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[a] Yield strength is defined as the stress which produces a permanent set of 0.2 per cent of the initial gage length.

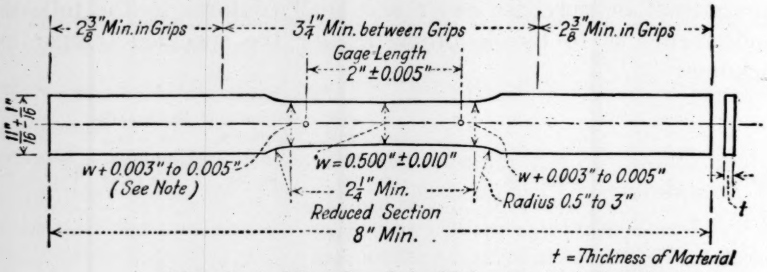
[b] For widths 36 in. or over in thicknesses from 0.021 to 0.040 in., inclusive, the elongation may be 17 per cent in 2 in.

Bend Tests

5. Bend test specimens shall stand being bent cold through an angle of 180 deg. around a pin the diameter of which is equal to *n* times the thickness of the sheet without cracking; the value of *n* being shown in the table in Section 4 for the different tempers and thicknesses. No bend test is required for material in thicknesses greater than 0.500 in.

Test Specimens

6. (*a*) *Tension Tests.*—Tension test specimens for sheet and plate in either of the tempers may be cut in any direction, irrespective of the direction of rolling. For sheet and plate under 0.500 in. in thickness the standard sheet tension test specimen shown in Fig. 1 shall be used. For plate 0.500 in. or over in thickness, the standard 0.505-in. diameter round specimen shown in Fig. 2 or a similar round specimen having the maximum possible dimensions proportional to those of the standard 0.505-in. diameter specimen shall be used.


2⅜" Min. in Grips
3¼" Min. between Grips
2⅜" Min. in Grips
Gage Length
2" ± 0.005"
11/16" ± 1/16"
w + 0.003" to 0.005"
(See Note)
w = 0.500" ± 0.010"
w + 0.003" to 0.005"
2¼" Min.
Reduced Section
Radius 0.5" to 3"
8" Min.
t
t = Thickness of Material
Note: Gradual Taper from Ends of Reduced Section to Middle.
All Machining Dimensions are Shown below and Testing Dimensions above Specimen.

The ends shall be symmetrical within 0.01 in.

FIG. 1.—Standard Tension Test Specimen for Sheet Metals.

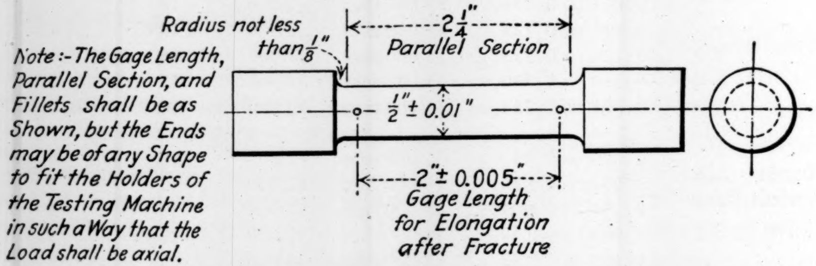

Radius not less than ⅛"
2¼"
Parallel Section
Note:- The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.
½" ± 0.01"
2" ± 0.005"
Gage Length for Elongation after Fracture

FIG. 2.—Standard 2-in. Gage Length Tension Test Specimen.

(*b*) *Bend Tests.*—Bend test specimens for sheet and plate in either of the tempers may be cut in any direction, irrespective of the direction of rolling. Bend test specimens from thin sheet and strip shall be of the full thickness, and in the case of strips 1 in. in width or under, of the full width of the material. The width of specimens from material over 1 in. in width shall be six times the thickness, but not less than 1 in. The edges may be rounded to a $\frac{1}{16}$-in. radius. When practicable the length shall be at least 6 in.

Number of Tests

7. One tension test specimen shall be taken to represent each 1000 lb. (453.6 kg.) or fraction thereof of sheet (thicknesses up to

0.258 in.); and one tension test specimen to represent each 2000 lb. (907.2 kg.) or fraction thereof of plate, or such other quantities as may be mutually agreed upon between the manufacturer and the purchaser. Bend test specimens for material up to 0.500 in. in thickness shall be taken in numbers equal to the tension test specimens.

PERMISSIBLE VARIATIONS IN THICKNESS

8. The thickness of sheet and plate shall not vary from that specified by more than the respective tolerances indicated in the following table:

SHEET

	18 in. in Width and Under	Over 18 to 36 in., Incl., in Width	Over 36 to 54 in., Incl., in Width	Over 54 to 72 in., Incl., in Width	Over 72 to 90 in., Incl., in Width	Over 90 to 102 in., Incl., in Width
Thickness, in.	Thickness Tolerances, plus or minus, in.					
0.250 to 0.129......	0.04T[a]	0.04T[a]	0.05T[a]	0.06T[a]	0.07T[a]	0.08T[a]
0.128 to 0.092......	0.004	0.0045	0.005	0.007	0.009	0.010
0.091 to 0.073......	0.003	0.003	0.004	0.006	0.008	......
0.072 to 0.051......	0.0025	0.003	0.004	0.005	0.007	......
0.050 to 0.037......	0.002	0.0025	0.003	0.004	......	......
0.036 to 0.018......	0.0015	0.002	0.0025	......	......	......
0.017 to 0.010......	0.0015	0.0015	0.002	......	......	......

PLATE

	54 in. in Width and Under	Over 54 to 72 in., Incl., in Width	Over 72 to 90 in., Incl., in Width	Over 90 to 120 in., Incl., in Width
Thickness, in.	Thickness Tolerances, plus or minus, per cent of Nominal Thickness			
3.000 to 1.001...........................	3	3	4	5
1.000 to 0.501...........................	4	4	5	6
0.500 to 0.251...........................	5	5	6	7
0.250 to 0.125...........................	5	6	7	8

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[a] T = the nominal thickness.

WORKMANSHIP AND FINISH

Workmanship and Finish

9. All sheet and plate shall be commercially flat and free from buckles; they shall be free from injurious surface defects and shall have a workmanlike finish.

INSPECTION AND REJECTION

Inspection and Rejection

10. The manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisy him that the material is being furnished in accordance with these specifications.

11. Material which fails to conform to these specifications will be rejected and the manufacturer shall be notified.

TENTATIVE SPECIFICATIONS
FOR
ALUMINUM-MANGANESE ALLOY SHEET AND PLATE[1]

A.S.T.M. Designation: B 79 – 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED AS TENTATIVE, 1930; ADOPTED, 1931; REISSUED AS TENTATIVE, 1933.[2]

Scope

1. These specifications cover aluminum-manganese alloy sheet and plate. Commercial flat sheet shall be supplied on orders for sheet, except where coiled or strip sheet is specifically ordered.

Manufacture

2. No scrap shall be used in the manufacture of aluminum-manganese alloy sheet and plate except such as shall accumulate at the manufacturer's plants from material of similar composition and of his own manufacture.

CHEMICAL COMPOSITION AND TESTS

Chemical Composition

3. The sheet and plate shall conform to the following requirements as to chemical composition:

Manganese, per cent	1.0 to 1.5
Copper, maximum, per cent	0.2
Aluminum, minimum, per cent	97.0

Samples

4. Samples for analysis shall be taken from a random sheet to represent each 1000 lb. (453.6 kg.) of sheet, and from a random plate to represent each 2000 lb. (907.2 kg.) of plate, or such other quantity as may be mutually agreed upon between the manufacturer and the purchaser. Samples for analysis may be obtained from the tension

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. J. A. Gann, Secretary of Committee B-7 on Light Metals and Alloys, Cast and Wrought, The Dow Chemical Co., Midland, Mich.

These specifications are in effect a revision of and replace the former Standard Specifications for Aluminum-Manganese Alloy Sheet (A.S.T.M. Designation: B 79 – 31) which were accordingly discontinued in 1933.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 16, 1933.

or bend test specimens described in Section 7. The sample for analysis may be prepared by shearing or by drilling or by machining without the use of any lubricant in such a manner as to give a sample representative of the entire cross-section of the sheet or plate. Samples so prepared shall be divided into three equal parts, each of which shall be placed in a sealed package, one for the manufacturer, one for the purchaser and one for an umpire if necessary.

PHYSICAL PROPERTIES AND TESTS

Tensile Requirements

5. (*a*) Sheet shall be supplied in the temper specified in the contract or purchase order and shall conform to the following requirements as to tensile properties for the specified temper and thickness:

TEMPER	THICKNESS, IN.	TENSILE STRENGTH, LB. PER SQ. IN.	ELONGATION IN 2 IN., MINIMUM, PER CENT
Soft	0.013 to 0.031	19 000 max.	20
	0.032 to 0.050	19 000 max.	23
	0.051 to 0.250	19 000 max.	25
Half hard	0.013 to 0.019	19 500 min.	3[a]
	0.020 to 0.031	19 500 min.	4[a]
	0.032 to 0.050	19 500 min.	5[a]
	0.051 to 0.113	19 500 min.	6[a]
	0.114 to 0.161	19 500 min.	7
	0.162 to 0.250	19 500 min.	8
Three-quarter hard	0.013 to 0.019	23 500 min.	1
	0.020 to 0.031	23 500 min.	2
	0.032 to 0.050	23 500 min.	3
	0.051 to 0.121	23 500 min.	4
Hard	0.013 to 0.019	27 000 min.	1
	0.020 to 0.031	27 000 min.	2
	0.032 to 0.050	27 000 min.	3
	0.051 to 0.128	27 000 min.	4

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[a] This value is required for flat sheet. For coiled sheet in the half-hard temper, the elongation may be less than that for flat sheet by 1 per cent in 2 in. The maximum thickness of coiled or strip sheet commercially available in the half-hard temper is 0.080 in.

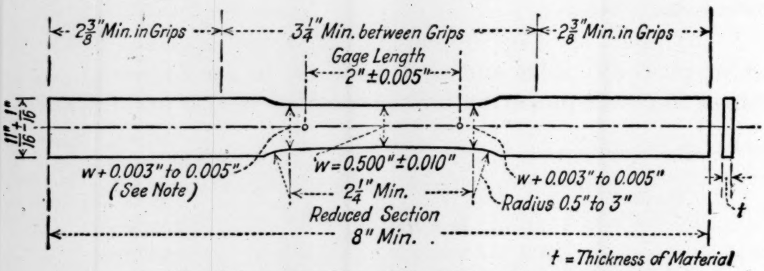
(*b*) Unless otherwise specified, plate (thicknesses 0.250 n. and over) shall be supplied as rolled (see Explanatory Note 2) and tension tests shall not be required.

(*c*) If so specified, plate shall be supplied in the soft temper in thicknesses from 0.250 to 3.000 in., in which case the tensile strength shall not exceed 19,000 lb. per sq. in. and the elongation shall not be less than 25 per cent in 2 in.

Bend Tests

6. (*a*) Bend test specimens taken from sheet in the soft or in the half-hard temper or from plate in the soft temper or "as rolled" shall stand being bent cold through 180 deg. flat on themselves without cracking.

(*b*) Bend test specimens taken from sheet in the three-quarter-hard temper shall stand being bent cold through 180 deg. around a pin having a diameter equal to four times the thickness of the sheet without cracking.

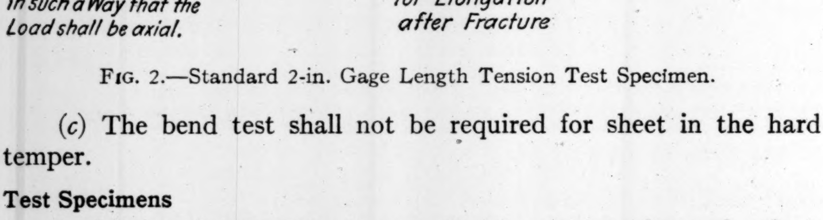


$2\frac{3}{8}$" Min. in Grips
$3\frac{1}{4}$" Min. between Grips
$2\frac{3}{8}$" Min. in Grips
Gage Length
2" ± 0.005"
$\frac{11}{16}$" ± $\frac{1}{16}$"
w + 0.003" to 0.005" (See Note)
w = 0.500" ± 0.010"
w + 0.003" to 0.005"
$2\frac{1}{4}$" Min. Reduced Section
Radius 0.5" to 3"
8" Min.
t
t = Thickness of Material

Note: Gradual Taper from Ends of Reduced Section to Middle.
All Machining Dimensions are Shown below and Testing Dimensions above Specimen.

The ends shall be symmetrical within 0.01 in.

FIG. 1.—Standard Tension Test Specimen for Sheet Metals.



Radius not less than $\frac{1}{8}$"
$2\frac{1}{4}$" Parallel Section
$\frac{1}{2}$" ± 0.01"
2" ± 0.005" Gage Length for Elongation after Fracture

Note:- The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.

FIG. 2.—Standard 2-in. Gage Length Tension Test Specimen.

(*c*) The bend test shall not be required for sheet in the hard temper.

Test Specimens

7. (*a*) *Tension Test Specimens.*—Tension test specimens for sheet in the half-hard temper shall be taken parallel to the direction of rolling; for sheet in the soft, three-quarter-hard and hard tempers the tension test specimens may be taken in any direction. (See Explanatory Notes 1 and 3.) For sheet and plate under 0.500 in. in thickness the standard sheet tension test specimen shown in Fig. 1 shall be used. For plate 0.500 in. or over in thickness, the standard 0.505-in.

diameter round specimen shown in Fig. 2 or a similar round specimen having the maximum possible dimensions proportional to those of the standard 0.505-in. diameter specimen shall be used.

(*b*) ***Bend Test Specimens.***—Bend test specimens may be taken in any direction from sheet in the soft, half-hard or three-quarter-hard temper and from plate in the soft temper or as rolled. Bend test specimens from thin sheet and strip shall be of the full thickness, and in the case of strips 1 in. in width or under, of the full width of the material. The width of specimens from material over 1 in. in width shall be six times the thickness, but not less than 1 in. The edges may be rounded to a $\frac{1}{16}$-in. radius. When practicable the length shall be at least 6 in. For plates over 0.500 in. in thickness a machined bend test specimen 1 by $\frac{1}{2}$ in. in cross-section and at least 6 in. in length shall be used. The edges may be rounded to a $\frac{1}{16}$-in. radius. When permitted by the inspector, the cross-section may be modified to $\frac{1}{2}$ in. square. In the case of plate $\frac{3}{4}$ in. or over in thickness, a $\frac{3}{4}$-in. round specimen machined from the material may be used. From plate $1\frac{1}{2}$ in. or over in thickness, the specimen shall be taken midway between the center and surface of the plate.

Number of Tests

8. One tension and one bend test specimen shall be taken from a random sheet to represent each 1000 lb. (453.6 kg.) of sheet, and from a random plate to represent each 2000 lb. (907.2 kg.) of plate, or such other quantity as may be mutually agreed upon between the manufacturer and the purchaser.

PERMISSIBLE VARIATIONS IN THICKNESS

Thickness

9. The thickness of flat sheet, coiled or strip sheet, and plate, shall not deviate from that specified by more than the respective tolerances indicated in the following table:

FLAT SHEET

THICKNESS, IN.	18 IN. IN WIDTH AND UNDER	OVER 18 TO 36 IN., INCL., IN WIDTH	OVER 36 TO 54 IN., INCL., IN WIDTH	OVER 56 TO 72 IN., INCL., IN WIDTH	OVER 72 TO 90 IN., INCL., IN WIDTH	OVER 90 TO 102 IN., INCL., IN WIDTH
	THICKNESS TOLERANCE, PLUS OR MINUS, IN.					
0.250 to 0.129......	0.04T[a]	0.04T[a]	0.05T[a]	0.06T[a]	0.07T[a]	0.08T[a]
0.128 to 0.092......	0.004	0.0045	0.005	0.007	0.009	0.010
0.091 to 0.073......	0.003	0.003	0.004	0.006	0.008	......
0.072 to 0.051......	0.0025	0.003	0.004	0.005	0.007	......
0.050 to 0.037......	0.002	0.0025	0.003	0.004	......	......
0.036 to 0.018......	0.0015	0.002	0.0025	......	......	......
0.017 to 0.010......	0.0015	0.0015	0.002	......	......	......

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[a] T = the nominal thickness.

Coiled Sheet

Thickness, in.	12 in. in Width and Under	Over 12 to 24 in., Incl., in Width	Over 24 in. in Width
	Thickness tolerance, plus or minus, in.		
0.128 to 0.103	0.0035	0.0035	0.004
0.102 to 0.091	0.003	0.003	0.004
0.090 to 0.073	0.003	0.003	0.003
0.072 to 0.051	0.0025	0.003	0.003
0.050 to 0.041	0.0025	0.0025	0.0025
0.040 to 0.030	0.002	0.0025	0.0025
0.029 to 0.019	0.002	0.002	0.002
0.018 to 0.011	0.0015	0.002	......
0.010 to 0.008	0.001	0.0015	......
0.007 to 0.006	0.001	0.001	......

Plate

Thickness, in.	54 in. in Width and Under	Over 54 to 72 in., Incl., in Width	Over 72 to 90 in., Incl., in Width	Over 90 to 120 in., Incl., in Width
	Thickness tolerance, plus or minus, per cent of nominal thickness			
3.000 to 1.001	3	3	4	5
1.000 to 0.501	4	4	5	6
0.500 to 0.251	5	5	6	7
0.250 to 0.125	5	6	7	8

Workmanship and Finish

Workmanship and Finish

10. All sheet and plate shall be commercially flat and free from buckles; they shall be free from injurious surface defects and shall have a workmanlike finish.

Inspection and Rejection

Inspection

11. The manufacturer shall afford the purchaser, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications.

Rejection

12. Material which fails to conform to these specifications will be rejected and the manufacturer shall be notified.

Explanatory Notes

Note 1.—In the case of sheet in the half-hard temper, there is an appreciable difference in the elongation depending upon the direction in which the test specimen is taken from the sheet. This measurement made parallel to the direction of final rolling is distinctly higher than if the specimen were cut perpendicular to this direction. This difference is not observed in hard or soft sheet. The inspection of half-hard sheet calls for the use of specimens parallel to the direction of final rolling because of the greater contrast with the values obtained from hard sheet. The fact that the bend test specimens may be taken without regard to the direction of rolling is evidence that the lower elongation across the grain does not indicate a lack of workability.

NOTE 2.—The mechanical properties of "as rolled" plate lie between those of the soft temper and those of the half-hard temper. Thinner plates (up to about 0.5 in.), because of the cooling during the rolling operation, have strengths which average around the minimum for half-hard temper. As the thickness increases the properties approach those of the soft temper. Where higher properties are required it is more economical to use a stronger aluminum alloy rather than to specify an intermediate temper (half-hard or quarter-hard) because of the cost of cold rolling heavy plates.

NOTE 3.—The use of grips which insure a uniform axial loading of the test specimen is essential, if satisfactory results are to be obtained.

TENTATIVE METHODS OF CHEMICAL ANALYSIS
OF
ALUMINUM AND LIGHT ALUMINUM ALLOYS[1]

A.S.T.M. Designation: B 40 – 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1921; REVISED, 1923, 1925, 1926, 1927, 1928, 1933.[2]

These methods of analysis contemplate the chemical analysis of aluminum and aluminum alloys as covered by standard and tentative specifications of the American Society for Testing Materials.

DETERMINATION OF SILICON

Solutions Required

1. The following solutions will be required:

(*a*) "*Acid Mixture.*"—Mix 1200 ml. of H_2SO_4 (25 per cent by volume), 600 ml. of HCl (sp. gr. 1.20) and 200 ml. of HNO_3 (sp. gr. 1.42).

(*b*) *Sulfuric Acid* (*25 per cent*).—Slowly stir 250 ml. of H_2SO_4 (sp. gr. 1.84) into distilled water and dilute to 1 liter.

Method

2. (*a*) Dissolve 1 g. of the well-mixed sample in 30 ml. of the acid mixture in a covered casserole or beaker (Note 1). When the drillings are completely dissolved, boil the solution to complete expulsion of HNO_3 and HCl and heat until copious fumes of H_2SO_4 have been given off for 5 minutes. Cool, and take up the residue with 10 ml. of H_2SO_4 (25 per cent) and 100 ml. of water. Boil to complete solution of the sulfates and filter (Note 2) on a low-ash filter paper using added low-ash filter paper pulp. Wash the residue with hot water until free from sulfates and ignite in a platinum crucible. Fuse the residue (Note 3) with not more than 2 g. of Na_2CO_3 and treat the fused mass in a casserole or beaker with sufficient H_2SO_4 (1:3) to prevent formation of solid cake of sodium sulfate when taken to fumes. The crucible should be washed and set aside. Evaporate the solution until it fumes strongly to separate the SiO_2. Cool, dilute to about 100 ml., warm till the salts are dissolved, filter the

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. E. E. Thum, Secretary of Committee B-2 on Non-Ferrous Metals and Alloys, 7016 Euclid Ave., Cleveland, Ohio.

[2] Latest revision accepted by Committee E-10 on Standards, September 2, 1933.

used pulp, wash well, ignite in a platinum crucible at 500 C. for removal of carbon, finish ignition at 1000 C., weigh. Moisten ash with water, add a few drops of H_2SO_4 (1:3), then add a few milliliters of HF, carefully evaporate till dry, ignite and again weigh.

(*b*) *Calculation.*—From the difference between the two weights deduct a blank obtained from the reagents and filter (Note 1). The rest of the loss in weight represents SiO_2 corresponding to the Si in the metal.

$$Si = SiO_2 \times 0.4672$$

NOTE 1.—Blanks should be carried along with all reagents and the proper corrections made.

NOTE 2.—Since there may be a slight loss of silicon in the filtrates from the silica filtrations, this amount may, for accurate work, be recovered by repeated evaporations of the filtrates.

NOTE 3.—In routine analysis, fusion of the first H_2SO_4 residue with Na_2CO_3 and subsequent treatment to the point of treating the ash with HF may be omitted. The first residue may be weighed and treated with HF, etc., as directed for the second H_2SO_4 residue. This, however, should not be done if the residue after ignition is dark colored.

DETERMINATION OF TITANIUM

Apparatus

3. Nessler tubes or some form of colorimeter will be required.

Solutions Required

4. The following solutions will be required:

(*a*) *Hydrogen Peroxide, U.S.P.*—This reagent must be free from HF.

(*b*) *Standard Titanium Solution.*—This solution is best prepared and standardized as follows:[1]

Potassium titanium fluoride, K_2TiF_6, best serves as the starting point for the preparation of the standard solution. Recrystallize a quantity from boiling water in platinum one or more times, dry, and preserve in a glass-stoppered bottle. Roughly weigh enough of the salt to provide a little more than 1 g. of TiO_2, transfer to a platinum dish, treat with 100 ml. of dilute sulfuric acid (1:1) and evaporate till fumes of sulfuric acid escape freely. Cool, wash down the sides of the dish, evaporate as before and then repeat the operation again to make sure that all hydrofluoric acid is expelled. Cool, and dilute with water to 1 liter. Withdraw two or more 50-ml. portions, dilute to 200 ml., heat to boiling and render faintly ammoniacal. Continue the boiling for 1 to 3 minutes, filter, and wash the precipitate with hot water until free from alkali salts. Ignite moist in the filter, finally over the blastlamp, and weigh. Calculate the TiO_2 content per milliliter of solution and affix the result to the bottle containing it. The stopper of the bottle should be coated with vaseline and the needed quantities of solution withdrawn by a dry pipette, never poured. In a solution so prepared there is not enough alkali sulfate to weaken the color when peroxidized.

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[1] Hillebrand and Lundell, "Applied Inorganic Analysis," p. 458, John Wiley and Sons, Inc., New York City.

Method

5. (*a*) See the "Determination of Silicon," Section 2. Fuse the non-volatile residue remaining after the silicon determination in a small amount of potassium bisulfate, take up in a small amount of H_2SO_4 (5 per cent) and add to the filtrates and washings from the silicon determination. Evaporate the solution to approximately 100 ml. and treat with 5 ml. of H_2SO_4 (sp. gr. 1.84) and 3 g. of iron-free zinc. Heat until the zinc is nearly dissolved and the reduction of copper is complete. Decant the solution into another beaker, wash the zinc and copper with hot water and continue the evaporation of the solution to approximately 75 ml. Cool and transfer to a 100-ml. Nessler comparison tube, add 5 ml. of H_2O_2 (3 per cent) and dilute to the 100-ml. mark. In another tube, place 88 ml. of H_2O, 5 ml. of H_2SO_4 (sp. gr. 1.84) and cool. Add 5 ml. of H_2O_2 (3 per cent) and then from a burette add the standard titanium solution until the colors match (Note).

(*b*) *Calculation.*—The volume of the standard solution required multiplied by 100 times its titre represents the percentage of titanium in the sample.

NOTE.—The filtrate and washings from the silicon determination should ordinarily be colorless. If light yellow owing to iron, the standard comparison solution should be brought to the same tint with ferric sulfate solution before adding the hydrogen peroxide.

In case the amount of titanium is high the solution may be diluted to a definite volume and aliquot portions taken for the colorimetric test.

DETERMINATION OF COPPER
BY THE
ELECTROLYTIC METHOD[1]

Apparatus[2]

6. (*a*) *Electrodes.*—The electrodes recommended are of the stationary and not of the rotating type, as the stationary require less

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[1] The electrolytic method is preferred for the determination of copper no matter what the percentage.

Copper, when present in small amounts, may also be determined by potassium cyanide titration. See the Standard Methods of Chemical Analysis of Alloys of Lead, Tin, Antimony and Copper (A.S.T.M. Designation: B 18) of the American Society for Testing Materials, 1933 Book of A.S.T.M. Standards, Part I, p. 822.

[2] This apparatus is identical with that used in the Standard Methods of Chemical Analysis of Manganese Bronze (A.S.T.M. Designation: B 27), see 1933 Book of A.S.T.M. Standards, Part I, p. 665.

operator's time and there is less chance for erroneous results to be obtained than with the other kind. Rapid and accurate results are obtained with stationary electrodes made from platinum gauze.

(*b*) *Cathodes.*—Platinum cathodes may be formed either from plain or perforated sheets, or from wire gauze, and may be either open or closed cylinders. They should give a depositing surface, counting both sides, of approximately 100 sq. cm. Gauze cathodes are recommended, and are best made from gauze containing approximately 400 meshes per sq. cm. (50 meshes per linear inch). The cathode should be stiffened by doubling the gauze for about 3 mm. at the top and at the bottom of the cylinder. The cylinder should be approximately 30 mm. in diameter and 30 mm. in height. The stem should be made from 1.14-mm. or 1.29-mm. wire, flattened and welded the entire width of the gauze; the height over all should be approximately 130 mm., and the gauze should be sand blasted.

(*c*) *Anodes.*—Platinum anodes may be of the spiral type when used in the determination of copper by electrolysis, or in the electrolytic determination of lead when it is present in amounts not over 0.2 per cent. When used in electrolytic determination of copper and lead together in samples containing 0.2 per cent lead or over, the anodes should be of wire gauze. Spiral anodes should be made from 1.02-mm. or 1.14-mm. wire formed into a spiral of 7 turns having a height of approximately 51 mm. and a diameter of 16 mm., the length over all being approximately 145 mm. Platinum gauze used in making anodes should contain approximately 400 meshes per sq. cm. (50 meshes per linear inch). The gauze should be formed into closed cylinders approximately 12 mm. in diameter and 30 mm. in height. The cylinders should be stiffened by doubling the gauze for about 3 mm. at the top and at the bottom. The stem should be made from 1.02-mm. or 1.29-mm. wire, flattened and welded the entire width of the gauze; the height over all should be approximately 137 mm., and the gauze should be sand blasted.

Solutions Required

7. The following solutions will be required:

(*a*) *Sodium Hydroxide Solution.*—Dissolve 250 g. of NaOH in distilled water and dilute to 1 liter.

(*b*) *Nitric Acid* (*1:1*).—Dilute 500 ml. of HNO_3 (sp. gr. 1.42) to 1 liter with distilled water.

Method

8. (*a*) Dissolve 10 g. of the sample in a large casserole or beaker with 150 ml. of the NaOH solution. This should be added in small

portions as the action is vigorous for a time. After the action slackens, complete solution may be hastened by warming. When no evidence of further reaction can be seen, dilute to about 700 ml. with water at the boiling temperature. Filter through a strong paper and wash (Note 1).

(*b*) Dissolve the residue from the paper with 25 ml. of hot HNO_3 (1:1) into a beaker for electrolyzing, and wash the filter thoroughly with hot water. Boil to expel oxides of nitrogen, add 6 to 8 ml. of H_2SO_4 (1:1), dilute to about 150 ml. and electrolyze. Use a weighed, sand-blasted cathode and a current of from 3 to 5 amp. When the solution is colorless and 1 ml. of the solution gives no copper test with hydrogen sulfide water on a porcelain plate, remove the solution from the electrodes quickly without interrupting the current (Note 2). Quickly rinse the cathode in distilled water and then dip it in two successive baths of alcohol. Shake off the excess alcohol and ignite the remainder by bringing it to the flame of an alcohol lamp. Keep the cathode moving continually while the alcohol burns. Weigh as metallic copper.

NOTE 1.—It is not anticipated that the aluminum will contain tin. In case tin has been found it will be preferable to precipitate with H_2S. The sulfides should then be dissolved, digested in HNO_3 (1:1), the metastannic acid filtered off and the electrolysis then carried out.

NOTE 2.—A staining of the anode indicates the presence of lead or manganese.

DETERMINATION OF COPPER
BY THE
IODIDE METHOD (OPTIONAL)

Solutions Required

9. The following solutions will be required:

(*a*) "*Acid Mixture.*"—Mix 1200 ml. of H_2SO_4 (25 per cent by volume), 600 ml. of HCl (sp. gr. 1.20) and 200 ml. of HNO_3 (sp. gr. 1.42).

(*b*) *Sulfuric Acid (25 per cent).*—Slowly stir 250 ml. of H_2SO_4 (sp. gr. 1.84) into distilled water and dilute to 1 liter.

(*c*) *Nitric Acid (1:1).*—Dilute 500 ml. of HNO_3 (sp. gr. 1.42) to 1 liter with distilled water.

(*d*) *Hydrogen Sulfide Wash Solution.*—Saturate a 1 per cent solution of H_2SO_4 with H_2S.

(*e*) *Acetic Acid (Glacial).*

(*f*) *Sulfuric Acid (sp. gr. 1.84).*

(*g*) *Potassium Iodide Solution.*—Dissolve 30 g. of potassium iodide in distilled water and dilute to 100 ml.

(*h*) *Sodium Thiosulfate Solution* (*0.05 N*).—Dissolve 12.41 g. of $Na_2S_2O_3$ $5H_2O$ in 1 liter of distilled water. 1 ml. should be equivalent to approximately 0.003 g. of copper. Store in an amber bottle.

(*i*) *Starch Solution.*—Make a paste of 1 g. of soluble starch in cold water, and add 150 ml. of hot water and boil 2 to 3 minutes. Cool before using. Make as required.

Method

10. Dissolve 2 g. of the sample in 55 ml. of the acid mixture as for the determination of silicon described in Section 2, and continue till the first silica filtrate has been obtained. Heat the filtrate to boiling and pass in a rapid stream of H_2S for 5 minutes. Filter through a low-ash filter paper, using a little paper pulp, and wash with hydrogen sulfide wash solution. Ignite in a porcelain crucible at 500 C. Transfer the residue to a 250-ml. Erlenmeyer flask, washing out the crucible with hot HNO_3 (1:1). Add a few drops of H_2SO_4 and evaporate until most of the H_2SO_4 has been driven off. Cool, add 3 ml. of acetic acid, 25 ml. of water, and boil gently until salts are in solution. Cool, add 10 ml. of KI solution, and titrate with standard sodium thiosulfate solution. A few drops of starch solution are added as an indicator near the end of the titration. Standardize the sodium thiosulfate solution by titrating aliquot portions of a solution of copper sulfate, whose copper content has been determined electrolytically.

DETERMINATION OF MANGANESE

Persulfate Method

(FOR SAMPLES CONTAINING UNDER 1.5 PER CENT OF MANGANESE.)

Solutions Required

11. The following solutions will be required.

(*a*) *Acid Mixture.*—Slowly stir 400 ml. of H_2SO_4 (sp. gr. 1.84) into distilled water, cool and add 400 ml. of HNO_3 (sp. gr. 1.42). Then dilute the mixture with distilled water to a total volume of 1 liter.

(*b*) *Silver Nitrate.*—Dissolve 1.33 g. of $AgNO_3$ in 1 liter of distilled water.

(*c*) *Stock Sodium Arsenite Solution.*—To 15 g. of arsenious oxide (As_2O_3) in a 300-ml. Erlenmeyer flask, add 45 g. of Na_2CO_3 and 150 ml. of distilled water. Heat the flask and contents on the steam bath until the As_2O_3 is dissolved. Cool the solution, filter and make up to 1 liter with distilled water.

(*d*) *Standard Sodium Arsenite Solution.*—Mix 200 ml. of the stock sodium arsenite solution with 2500 ml. of distilled water, and standardize against a measured volume of a standard $KMnO_4$ solution that has been reduced and treated as in the method, or against a suitable standard metal or alloy of the U. S. Bureau of Standards. One cubic centimeter of this solution should be equivalent to approximately 0.00035 g. of manganese.

(*e*) *Ammonium Persulfate.*—Dissolve 6 g. of ammonium persulfate $(NH_4)_2S_2O_8$, in 100 ml. of distilled water. This solution should be made up as needed as it deteriorates rapidly (Note).

NOTE.—The ammonium persulfate must be tested for its strength. A good grade should contain about 95 per cent of $(NH_4)_2S_2O_8$; some lots contain no more than 25 per cent of the salt.

Method

12. Use 1 g. of the sample if the manganese is not over 0.2 per cent (Note). For a higher manganese content adjust the size of sample so that it will not contain more than 0.002 g. of manganese. Place it in a 250-ml. Erlenmeyer flask with 30 ml. of the acid mixture and heat until solution is complete. Boil until oxides of nitrogen are expelled. Dilute to 100 ml. with boiling-hot water, add 20 ml. of $AgNO_3$ solution and 30 ml. of the persulfate solution, then remove to a moderately warm place to stand for a few minutes for complete development of the permanganic acid. Cool to below 25 C. and titrate with the standard sodium arsenite solution to the disappearance of the pink color.

NOTE.—Large amounts of permanganic acid are unstable; on that account samples which contain large amounts of manganese should have correspondingly small samples weighed out.

If it is desired, larger amounts of the sample can be used and correspondingly greater amounts of $AgNO_3$ and $(NH_4)_2S_2O_8$ (preferably in the form of stronger solutions).

Bismuthate Method

(OPTIONAL.)

(FOR SAMPLES CONTAINING LESS THAN 1.50 PER CENT MANGANESE.)

Solutions Required

13. The following solutions will be required:

(*a*) *Acid Mixture.*—Slowly stir 400 ml. of H_2SO_4 (sp. gr. 1.84) into distilled water, cool and add 400 ml. of HNO_3 (sp. gr. 1.42). Then dilute the mixture with distilled water to a total volume of 1 liter.

(*b*) *Nitric Acid (1:3).*—Dilute 250 ml. of HNO_3 (sp. gr. 1.42) to 1 liter with distilled water.

(*c*) *Dilute Nitric Acid (3 per cent).*—Dilute 30 ml. of HNO_3 (sp. gr. 1.42) to 1 liter with distilled water.

(*d*) *Standard Permanganate Solution.*—Dissolve 1 g. of $KMnO_4$ in 1 liter of distilled water. Allow it to stand for at least one week and then filter through purified asbestos. Standardize against 0.1 g. portions of pure sodium oxalate. One cubic centimeter of this solution should be equal to approximately 0.00035 g. of manganese.

(*e*) *Standard Ferrous Ammonium Sulfate Solution.*—Dissolve 12.4 g. of ferrous ammonium sulfate crystals in 950 ml. of distilled water, and add 50 cc. of H_2SO_4 (sp. gr. 1.84).

Method

14. (*a*) In a 250-ml. Erlenmeyer flask, dissolve 1 g. of the sample (Note 1) in 30 ml. of acid mixture by warming on a water bath until solution is complete.

(*b*) When solution is complete heat to expel all oxides of nitrogen and cool. Dilute with 50 ml. of HNO_3 (1:3) and add 0.5 g. of sodium bismuthate (Note 2). Heat for a few minutes until the purple color has disappeared with or without the precipitation of manganese dioxide. Add a little ferrous ammonium sulfate solution until the solution becomes clear, and boil until the oxides of nitrogen are expelled. Cool, add an excess of sodium bismuthate and agitate for a few minutes. Add 50 ml. of 3 per cent HNO_3, and filter through an alundum crucible or an asbestos pad (Note 3). Wash with 50 ml. of HNO_3 (3 per cent). Add from a pipette or a burette 10 to 50 ml. (depending on the amount of permanganic acid) of ferrous ammonium sulfate solution and titrate with the $KMnO_4$ solution (Note 4).

(*c*) In exactly the same manner carry through a blank determination, using the same amounts of acid mixture of HNO_3 (1:3) and of sodium bismuthate as was done with the regular sample. Finally, add the exact volume of ferrous ammonium sulfate employed and titrate with the $KMnO_4$ solution.

(*d*) *Calculation.*—The difference between the volumes required in the two titrations represents the manganese in the sample, and the percentage is found by multiplying this volume by 100 times the manganese titre of the permanganate solution.

NOTE 1.—Large amounts (above 0.01 g. of manganese per 100 cc. of solution) of permanganic acid are unstable; the method can be used with satisfaction for alloys containing high percentages of manganese by decreasing the size of the sample.

NOTE 2.—The sodium bismuthate reagent should be tested for manganese and used only if its absence is shown.

NOTE 3.—The filtrate from the bismuthate must be perfectly clear, as the least particle of bismuthate carried into the filtrate will vitiate the results.

The solution must be cold at time of filtration and titration.

NOTE 4.—Instead of employing the method of reducing permanganic acid by means of standardized ferrous ammonium sulfate solution and titrating the excess of the reagent, it is possible to reduce the permanganic acid by standard sodium-arsenite solution. See the determination of manganese by the persulfate method, Sections 11 and 12.

DETERMINATION OF IRON

Solutions Required

15. The following solutions will be required:

(*a*) *"Acid Mixture."*—Mix 1200 ml. of H_2SO_4 (25 per cent by volume), 600 ml. of HCl (sp. gr. 1.20) and 200 ml. of HNO_3 (sp. gr. 1.42).

(*b*) *Tartaric Acid Solution.*—Dissolve 25 g. of tartaric acid in distilled water and dilute to 100 ml.

(*c*) *Hydrogen Sulfide Wash Solution.*—Saturate a 1 per cent solution of H_2SO_4 with H_2S.

(*d*) *Dilute Ammonium Salt Wash Solution.*—Neutralize a 1 per cent solution of sulfuric acid with ammonium hydroxide and add a slight excess of the latter reagent. Pass H_2S through this solution short of saturation. Use only freshly made solution.

(*e*) *Standard Potassium Permanganate Solution.*—Dissolve 1 g. of $KMnO_4$ in 1000 ml. of H_2O, and allow to stand for several days in a glass-stoppered bottle in a dark closet. Filter the solution through prepared asbestos and standardize against 0.1000-g. portions of pure sodium oxalate. Each milliliter is equivalent to approximately 0.00177 g. of iron.

Method

16. Dissolve 1 g. of the sample in an acid mixture as for the determination of silicon described in Section 2, and continue till the first residue has been ignited. Volatilize the silica and silicon by heating with a little hydrofluoric, nitric, and sulfuric acids; evaporate to fumes, and add to the original filtrate. If desired, the filtrate and residue from the silicon determination may be used instead of a separate sample. Stir in 25 ml. of the tartaric acid solution (25 per cent) (Note 1). Pass in H_2S and filter off the precipitate, washing with hydrogen sulfide water. Add NH_4OH to the filtrate in small excess. Treat with H_2S for one minute, warm to coagulate the precipitated sulfide, then cool, filter and wash with dilute ammonium salt wash solution. Dissolve the sulfide from the filter with 40 ml. of warm H_2SO_4 (1:6), washing the paper thoroughly with hot water. Boil until all H_2S is expelled. To the hot solution add a strong solution of $KMnO_4$ by drops till a small excess is shown by a pink color which

persists. Reduce with H_2S and place flask upon hot plate. Add four or five solid glass beads of approximately 5 mm. in diameter to prevent bumping. To remove H_2S, boil vigorously until volume is reduced 50 per cent. Cool and titrate with the standard potassium permanganate solution (Note 2).

NOTE 1.—The effect of tartaric acid is to form complexes with aluminum, vanadium, chromium, titanium, etc., preventing their precipitation as hydroxides.

NOTE 2.—Results of titration should be checked with a blank determination made on corresponding amounts of solutions used.

Iron may be directly determined on the filtrate obtained from the insoluble residue in the determination of silicon. Add strong potassium permanganate solution by drops until a pink color persists. Reduce with H_2S, boil out H_2S and titrate as in the formal method.

DETERMINATION OF LEAD

Electrolytic Method

Solutions Required

17. The following solutions will be required:

(*a*) *Hydrochloric Acid* (*sp. gr. 1.19*).

(*b*) *Nitric Acid* (*sp. gr. 1.42*).

(*c*) *Ammonia Water* (*sp. gr. 0.90*).

(*d*) *Tartaric Acid Solution.*—Dissolve 25 g. of tartaric acid in distilled water and dilute to 100 ml.

(*e*) *Formic Acid Mixture.*—Dilute 200 ml. of formic acid (sp. gr. 1.20) to 970 ml. with distilled water and add 30 ml. of ammonia water (sp. gr. 0.90).

(*f*) *Dilute Formic Acid Mixture Wash Solution.*—Dilute 25 ml. of the formic acid mixture to 1 liter with distilled water and saturate with H_2S.

(*g*) *Nitric Acid* (*1:1*).—Dilute 500 ml. of HNO_3 (sp. gr. 1.42) to 1 liter with distilled water.

Method

18. Weigh a 2-g. sample into a 400-ml. beaker, cover with 100 ml. of distilled water and add 20 ml. of HCl. When reaction subsides, add 1 ml. of concentrated HNO_3. Boil to complete solution. Dilute to 150 ml. with hot water, filter with a little pulp and wash with hot water. To the filtrate add 50 ml. of tartaric acid solution; make just neutral to methyl red with ammonia water. Add 25 ml. of formic acid mixture. Heat to boiling and pass in a rapid stream of H_2S for 15 minutes. Let settle a short time and then filter through a low-ash filter paper with a little paper pulp. Wash with dilute formic acid wash solution and ignite in a porcelain crucible at 500 C. Trans-

fer the residue to a 200-ml. tall form beaker with the aid of a little water and digest with 3 ml. of ammonia water for 5 minutes. Wash out the crucible with hot HNO_3 (1:1) and add sufficient HNO_3 (1:1) to make a total of 20 ml. Boil to solution, dilute to 150 ml. with hot water and electrolyze. Use a weighed anode and a current of 0.5 amp. When electrolysis is complete, remove solution quickly from electrode without interrupting the current and quickly rinse the anode in distilled water, then dip into two successive baths of alcohol. Shake off excess alcohol and dry at 210 C. for 30 minutes. Cool and weigh as PbO_2.

$$Pb = PbO_2 \text{ (Empirical)} \times 0.8643$$

DETERMINATION OF MAGNESIUM

Apparatus

19. *Mercury Cathode Equipment.*—This may be a simple 400-ml. beaker with 20 to 25 ml. of mercury in the bottom which is connected by a platinum wire so as to form the cathode. The anode is a plain platinum spiral. A Melaven cell may be used.

Solutions Required

20. The following solutions will be required:

(*a*) *Sodium Hydroxide.*—Dissolve 250 g. of NaOH (C. P. pellets) in 1 liter of distilled water.

(*b*) *Nitric Acid (sp. gr. 1.42).*

(*c*) *Sulfuric Acid (1:1).*—Add 500 ml. of H_2SO_4 (sp. gr. 1.84) to 500 ml. of distilled water and cool.

(*d*) *Hydrochloric Acid (sp. gr. 1.19).*

(*e*) *Hydrochloric Acid (1:1).*—Dilute 500 ml. of HCl to 1 liter with distilled water.

(*f*) *Bromine Water.*—Saturate 100 ml. of distilled water with bromine.

(*g*) *Ammonium Chloride Wash Solution.*—Neutralize HCl (1 per cent) with NH_4OH, adding 0.5 ml. per liter in excess.

(*h*) *Ammonium Oxalate.*—Saturate 100 ml. of distilled water with ammonium oxalate $(NH_4)_2C_2O_4$.

(*i*) *Di-ammonium Phosphate.*—Saturate 100 ml. of distilled water with di-ammonium phosphate $(NH_4)_2HPO_4$.

(*j*) *Ammonia Water (sp. gr. 0.90).*

Method

21. (*a*) Dissolve 10 g. of the sample (Note 1) in a large casserole or beaker with 150 ml. of NaOH solution. This should be added in small portions, as the action is vigorous for a time. After the action slackens, complete solution may be hastened by warming. When no evidence

of further reaction can be seen, dilute to about 700 ml. with water at boiling temperature. Filter through a strong paper and wash well with hot water. Wash the residue back into the original beaker. Wash the paper with hot HCl (1:1) and a few milliliters of HNO_3. Add 20 ml. of H_2SO_4 (1:1) and evaporate to copious fumes. Cool, dilute to 100 ml. with hot water. Boil until all salts are in solution, allow to settle and filter while hot with a little filter paper pulp. Wash well with hot water.

(*b*) To the filtrate add NH_4OH until a slight permanent precipitate forms, warm and add H_2SO_4 (1:1) dropwise till the precipitate redissolves. Make up to 200 ml. and electrolyze with 0.20 amp. in 16 hr. Decant, wash the mercury with cold water, and filter.

(*c*) To the electrolyte add 10 ml. of concentrated HCl and make just alkaline with NH_4OH to methyl red. Filter, wash with ammonium chloride wash solution, return the paper to the beaker, add 10 ml. of HCl (1:1). Macerate the paper, dilute to 100 ml., make just alkaline to methyl red with NH_4OH. Filter and wash. Add 1 g. of ammonium persulfate, $NH_4S_2O_8$, 1 ml. of NH_4OH, and heat to boiling. Filter with a little paper pulp and wash with hot water.

(*d*) Adjust the volume to 150 ml. and add 10 ml. of saturated ammonium oxalate solution, make alkaline with NH_4OH and warm for 1 hr., keeping the solution ammoniacal and the volume not over 100 ml. Filter through a low-ash filter paper and wash with a small amount of hot water.

(*e*) Make the filtrate just acid with HCl, then add 20 ml. of saturated di-ammonium phosphate. Cool and add NH_4OH drop by drop, while stirring vigorously (avoid hitting the glass sides), until the precipitate can no longer be seen to form. Then add excess ammonia up to one-tenth of the volume of the solution.

(*f*) Allow the solution to stand at least 8 hr. and overnight, if possible, then filter, using a low-ash paper pulp. Use an ashless, close-textured paper and wash with ammonia (2 per cent). (See Note 2.) Dry, burn in a small crucible, ignite at 1000 C., cool, weigh as $Mg_2P_2O_7$ and calculate Mg.

$$Mg = Mg_2P_2O_7 \times 0.2184 \quad \text{Deduct Blank.}$$

NOTE 1.—For 0.05 to 0.10 g. of magnesium use 10 g. of sample; for 0.10 to 0.15 g. of magnesium use 5 g. of sample, and for a magnesium content over 0.15 g. use 2 g. of sample.

Adjust method of decomposition to suit.

NOTE 2.—In many cases, it is advisable to redissolve and reprecipitate, particularly where magnesium is unusually high.

DETERMINATION OF ZINC (UNDER 1 PER CENT)

Ammonium Mercuric Thiocyanate Method

Solutions Required

22. The following solutions will be required:

(*a*) *Sulfuric Acid (1:1).*—Slowly stir 500 ml. of H_2SO_4 into 500 ml. of distilled water and cool.

(*b*) *Hydrochloric Acid (sp. gr. 1.19).*

(*c*) *Nitric Acid (sp. gr. 1.42).*

(*d*) *Hydrogen Sulfide Water.*—Saturate an HCl (1 per cent) solution with H_2S, as required.

(*e*) *Ammonia Water (sp. gr. 0.90).*

(*f*) *Formic Acid Mixture.*—Dilute 200 ml. of formic acid (sp. gr. 1.20) and 30 ml. of ammonia to 1 liter with distilled water.

(*g*) *Dilute Formic Acid Mixture Wash Solution.*—Dilute 25 ml. of the formic acid mixture to 1 liter with distilled water and saturate with H_2S.

(*h*) *Hydrochloric Acid (1:3).*—Dilute 250 ml. of HCl (sp. gr. 1.19) to 1 liter with distilled water.

(*i*) *Tartaric Acid.*—Dissolve 25 g. of tartaric acid in distilled water and dilute to 100 ml.

(*j*) *Ammonium Mercuric Thiocyanate.*—Dissolve 32 g. of ammonium thiocyanate in 200 ml. of distilled water. Stir in 27 g. of mercuric chloride while diluting to 500 ml. Settle two days and filter off the slight yellow sediment formed.

Method

23. (*a*) Weigh a 2-g. sample into a 400-ml. beaker, cover with 100 ml. of water and add 20 ml. of concentrated HCl. When reaction subsides add 1 ml. of HNO_3. Boil to complete solution of copper. Dilute to 200 ml., add 5 ml. of concentrated HCl, and pass in a rapid stream of H_2S for 3 minutes. Filter with small amount of paper pulp and wash with hydrogen sulfide water. Boil the filtrate 10 minutes to expel H_2S, cool somewhat, and add 50 ml. of tartaric acid solution. Dilute to 300 ml. and make just neutral to methyl red with ammonia water. Then add 25 ml. of formic acid mixture, heat to boiling and pass in a rapid stream of H_2S for 15 minutes. Settle a short time and filter through a low-ash filter paper with a little paper pulp. Wash with dilute formic acid mixture wash solution.

(*b*) Dissolve the precipitate into the original beaker with hot HCl (1:3), washing the paper thoroughly with hot water. Add 10 ml. of H_2SO_4 (1:1) and evaporate to fumes. Cool, dilute to 100 ml. and filter. Add 25 ml. of ammonium mercuric thiocyanate solution. Stir vigorously and allow to stand overnight.

(*c*) Filter off the precipitate (Note) on a weighed Gooch crucible, wash with ammonium mercuric thiocyanate solution (1 per cent) and dry for 1 hr. at 110 C. Deduct blank and calculate zinc.

$$\text{Zn} = \text{Empirical factor} - \text{zinc mercuric thiocyanate} \times 0.1289$$

NOTE.—While the color of the precipitate should be white, in practice one of a lilac to purple color is often found. Apparently, in the field for which this method is particularly recommended (Zn in amounts less than 20 mg.), the color has no appreciable effect on the desired accuracy.

DETERMINATION OF ZINC (OVER 1 PER CENT)

Oxide Method

Solutions Required

24. The following solutions will be required:

(*a*) *Sulfuric Acid (1:1)*.—Slowly stir 500 ml. of H_2SO_4 into 500 ml. of distilled water and cool.

(*b*) *Hydrochloric Acid (sp. gr. 1.19)*.

(*c*) *Nitric Acid (sp. gr. 1.42)*.

(*d*) *Hydrogen Sulfide Wash Solution*.—Saturate an HCl (1 per cent) solution with H_2S.

(*e*) *Ammonia Water (sp. gr. 0.90)*.

(*f*) *Formic Acid Mixture*.—Dilute 200 ml. of formic acid (sp. gr. 1.20) to 970 ml. with distilled water and add 30 ml. of ammonia water (sp. gr. 0.90).

(*g*) *Dilute Formic Acid Mixture Wash Solution*.—Dilute 25 ml. of the formic acid mixture to 1 liter with distilled water and saturate with H_2S.

(*h*) *Hydrochloric Acid (1:3)*.—Mix 250 ml. of HCl (sp. gr. 1.19) with 750 ml. of distilled H_2O.

(*i*) *Tartaric Acid Solution*.—Dissolve 25 g. of tartaric acid in distilled water and dilute to 100 ml.

Method

25. (*a*) Weigh a 2-g. sample into a 400-ml. beaker, cover with 100 ml. of water and add 20 ml. of concentrated HCl. When reaction subsides, add 1 ml. of HNO_3. Boil to complete solution of copper. Dilute to 200 ml., add 5 ml. of concentrated HCl, and pass in a rapid stream of H_2S for 3 minutes. Filter with a small amount of paper pulp and wash with hydrogen sulfide water. Boil the filtrate 10 minutes to expel H_2S, cool somewhat, and add 50 ml. of tartaric acid solution. Dilute to 300 ml. and make just neutral to methyl red with ammonia water. Then add 25 ml. of formic acid mixture, heat to boiling and pass in a rapid stream of H_2S for 15 minutes. Settle a

short time and filter through a low-ash filter paper with a little paper pulp. Wash with dilute formic acid mixture wash solution.

(*b*) Dissolve the precipitate into the original beaker with hot HCl (1:3), washing the paper thoroughly with hot water. Add 10 ml. of H_2SO_4 (1:1) and evaporate to fumes. Cool, dilute to 100 ml., bring to a boil, filter with a little paper pulp and wash. To the filtrate add 10 ml. of tartaric acid solution and make just neutral to methyl red with ammonia water. Pass in a rapid stream of H_2S for 3 minutes, add 10 ml. of formic acid mixture, and pass a stream of H_2S for 5 additional minutes. Settle for a short time, filter through a low-ash filter paper, using paper pulp. Wash with dilute formic acid wash solution, and ignite at 700 C. in a porcelain crucible. Weigh as zinc oxide. Transfer the zinc oxide to a 200-ml. tall form beaker and dissolve in 20 ml. of HNO_3 (1:1). Dilute to 150 ml. with hot water and deposit PbO_2 on a weighed anode with a current of 0.5 amp.

$$PbSO_4 = PbO_2 \times 1.268$$

Deduct $PbSO_4$ and a determined blank from weight of impure ZnO.

$$Zn = ZnO \times 0.8034$$

DETERMINATION OF TIN

Apparatus

26. A 500-ml. Erlenmeyer flask with a 1-hole stopper carrying a glass tube, bent so that the outer end may be immersed in a solution of sodium bicarbonate, will be required.

Solutions Required

27. The following solutions will be required:

(*a*) *Hydrochloric Acid* (*sp. gr. 1.19*).

(*b*) *Hydrochloric Acid* (*1:1*).—Dilute 500 ml. of HCl (sp. gr. 1.19) to 1 liter with distilled water.

(*c*) *Sodium Bicarbonate Solution.*—Saturated solution of $NaHCO_3$ in distilled water.

(*d*) *Starch Solution.*—Make a paste of 1 g. of starch in cold water and add 150 ml. of hot water and boil for 2 to 3 minutes. Cool before using. Make as required.

(*e*) *Potassium Iodate.*—Prepare by dissolving 1.8 g. of KIO_3, 20 g. of KI and 2 g. of KOH in water and diluting to 1 liter. Standardize the solution with a mixture of weighed amounts of pure tin and tin-free aluminum.

Method

28. (*a*) Place 1 to 2 g. of the sample in a 500-ml. Erlenmeyer flask with 0.25 g. of pure granulated antimony. Add 50 ml. of

water and 50 ml. of concentrated HCl, insert the stopper and arrange so that the outer end of the tube dips into a beaker filled with saturated sodium bicarbonate solution. After the first rapid reaction is over, boil 10 minutes to complete solution of tin.

(*b*) Cool the flask in cold water with the tube still dipping in $NaHCO_3$ solution. The latter will be drawn in as the flask cools, supplying CO_2 to prevent entrance of air. When cold, open the flask and without delay add 0.5 g. of KI, 2 or 3 ml. of fresh starch solution, and titrate to a blue color with standard KIO_3 (Note). Deduct a determined blank.

NOTE.—If the alloy contains sufficient silicon to obscure the end point, dissolve in 50 ml. of HCl (1:1), boil and filter into a 500-ml. Erlenmeyer flask, washing with hot water. Add 1 g. of tin-free aluminum, 0.25 g. of antimony, 50 ml. of HCl and proceed as in the formal method.

TENTATIVE SPECIFICATIONS

FOR

MAGNESIUM INGOT AND STICK FOR REMELTING[1]

A.S.T.M. Designation: B 92 – 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1933.[2]

Scope

1. These specifications cover magnesium ingot and stick in one grade containing not less than 99.8 per cent magnesium.

NOTE.—Magnesium ingot and stick are normally furnished in the following commercial forms unless otherwise specified in the contract:

Form	Size and Shape Diameter, in.	Size and Shape Length, in.	Approximate Weight, lb.
Ingot	4	by 16	12.0
Stick	0.65	by 12	0.25
	0.92	by 12	0.50
	1.3	by 12	1.0
	1.3	by 24	2.0

Manufacture

2. No scrap shall be used in the production of magnesium ingot and stick, except such as shall accumulate at the manufacturer's plants from material of similar composition and of his own manufacture.

3. Magnesium ingot and stick shall have a clean surface and shall be commercially free from dirt, slag, or other foreign material.

Chemical Composition

4. The material shall conform to the following requirements as to chemical composition:

Total of Aluminum, Copper, Iron, Manganese, Nickel, Silicon, max., per cent	0.20
Total of Copper and Nickel, max., per cent	0.05
Magnesium, by difference, min., per cent	99.80

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. J. A. Gann, Secretary of Committee B-7 on Light Metals and Alloys, Cast and Wrought, The Dow Chemical Co., Midland, Mich.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 16, 1933.

Claims

5. Claims to be considered shall be made in writing within thirty days of receipt of material at the purchaser's plant and the results of the purchaser's tests shall be given. The seller shall within ten days of receipt of such claims either agree to satisfy the claims or send a representative to the purchaser's plant to endeavor to reconcile the differences. In the event of failure to reach an agreement the shipment shall be sampled as follows:

If the magnesium was shipped in carload lots, random samples shall be taken, but not less than four ingots from each car. If the shipment is less than carload lots, one ingot shall be taken from each 10,000 lb. or fraction thereof.

Sampling for Umpire Analysis

6. The ingot or stick selected shall be sawed or machined completely through with a clean tool. The sample so obtained shall represent the average cross-section of the material. No lubricant shall be used in this sampling operation. The metal chips shall be thoroughly mixed and the sample for analysis shall not be less than 100 g. Samples so taken shall be sealed and submitted to a mutually agreed upon umpire, whose determination shall be final.

Settlement of Claims

7. The expense of the umpire analysis shall be paid by the loser, or divided in proportion to the concession made in case of a compromise. In case of rejection being established, the damage shall be limited to the payment of freight both ways by the seller for the substitution of an equivalent weight of metal meeting these specifications.

TENTATIVE METHOD

OF

DETERMINATION OF PHOSPHORUS IN COPPER-BASE ALLOYS IN INGOT FORM FOR SAND CASTINGS[1]

A.S.T.M. Designation: B 45 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1933.[2]

DETERMINATION OF PHOSPHORUS

Solutions Required

1. The following solutions will be required:

(*a*) *Ferric Chloride Solution.*—Dissolve 25 g. of hydrated ferric chloride crystals in distilled water and make up to 1 liter. 1 ml. is equivalent to 0.005 g. Fe (approximately).

(*b*) *Dilute Ammonia for Washing.*—Dilute 100 ml. of NH_4OH (sp. gr. 0.90) to 1 liter with distilled water.

(*c*) *Ammonium Molybdate:* Prepare Solutions Nos. 1 and 2, as follows:

Solution No. 1.—Place in a large beaker 135 g. of 85 per cent molybdic acid and mix it thoroughly with 320 ml. of distilled water, add 187 ml. of NH_4OH (sp. gr. 0.90) and 80 ml. of HNO_3 (sp. gr. 1.42).

Solution No. 2.—Mix 535 ml. of HNO_3 (sp. gr. 1.42) and 1280 ml. of distilled water.

When the solutions are cold, add Solution No. 1 to Solution No. 2, stirring constantly, then add 0.1 g. of ammonium phosphate dissolved in 10 ml. of distilled water, and let stand at least 24 hr. before using. Keep the solution in a cool place and always filter before using. This makes 2.5 liters of solution.

(*d*) *Ferric Alum Solution.*—Dissolve 250 g. of c.p. ferric ammonium sulfate crystals in 2500 ml. of distilled water. Then add slowly, while stirring, 63 ml. of H_2SO_4 (sp. gr. 1.84) and 100 ml. of phosphoric acid (85 per cent).

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. E. E. Thum, Secretary of Committee B-2 on Non-Ferrous Metals and Alloys, 7016 Euclid Avenue, Cleveland, Ohio.

This method, when adopted as standard, will be added to the present Standard Methods of Chemical Analysis of Brass Ingots and Sand Castings (A.S.T.M. Designation: B 45 - 27), 1933 Book of A.S.T.M. Standards, Part I, p. 621.

[2] Accepted for publication as tentative by Committee E-10 on Standards, September 2, 1933.

(*e*) *Acid Ammonium Sulfate Wash Solution.*—Add 15 ml. of NH_4OH (sp. gr. 0.90) to about 700 ml. of distilled water. Then add 25 ml. of H_2SO_4 (sp. gr. 1.84) and make up to 1 liter.

(*f*) *Standard Potassium Permanganate Solution.*—Dissolve from 3.0 to 3.2 g. of c.p. potassium permanganate in 1 liter of distilled water. To standardize, weigh out from 0.25 to 0.30 g. of sodium oxalate (prepared according to Sörensen) into a 400-ml. beaker, dissolve in 200 ml. of distilled water, add 10 ml. of H_2SO_4 (1:1), heat on a hot plate to 90 to 95 C. and titrate slowly with the permanganate solution to a pink coloration that is permanent for 1 minute. The amount of phosphorus in grams per milliliter of solution shall be calculated by means of the following formula:

$$\text{Grams of phosphorus per milliliter of solution} = \frac{A \times 0.8334}{B} \times 0.01544$$

where A = the weight of sodium oxalate;

B = the amount of solution used in milliliters;

0.8334 = conversion factor of sodium oxalate to Fe; and

$$0.01544 = \text{conversion factor of Fe to } P = \frac{P}{36\ \text{Fe}}.$$

Method

2. (*a*) In a 400-ml. beaker, dissolve 5 g. of brass in 25 ml. of HNO_3 (sp. gr. 1.42) and 10 ml. of HCl (sp. gr. 1.19). When the action has ceased, boil until the oxides of nitrogen are expelled, add a little distilled water and continue boiling if necessary to dissolve lead chloride that might be present. Add about 5 g. of ammonium chloride and 25 ml. of the ferric chloride solution. Dilute to 250 ml., make just ammoniacal, and bring to a boil.

(*b*) Prepare a 91-mm. outside diameter Büchner filter funnel by placing an 11-cm. paper over a 9-cm. paper, both being closely woven. Allow some of the precipitate to deposit on the paper by gravity and then apply gentle suction. Continue the filtration and wash the precipitate two or three times, first with dilute ammonia and then with hot water. Place papers and precipitate in the original beaker and cover with 50 ml. of dilute HCl (1 part HCl to 2 parts of H_2O) and allow to digest on a steam bath for 15 minutes. Filter off the pulp through a loosely woven paper into a 400-ml. beaker and wash thoroughly with hot water. Adjust the volume to from 250 to 300 ml., bring to 90 C. and pass in H_2S for 30 minutes. Allow the precipitated sulfides to coagulate for 4 hr. and then filter through a closely woven paper into a 600-ml. beaker, washing with water saturated with H_2S and containing a few drops of HCl.

(*c*) Boil off H_2S from the filtrate and evaporate to a volume of 150 ml., then transfer to a 500-ml. Erlenmeyer flask. Oxidize by boiling a few minutes with 1 or 2 ml. of a potassium permanganate solution and then destroy the excess permanganate with a few drops of sodium nitrite (10 per cent) solution. Boil for 2 to 3 minutes to destroy any excess of the reducing agent. Make just ammoniacal and then just acid with HNO_3 adding 10 ml. in excess.

(*d*) Cool to 60 C. and add 60 ml. of ammonium molybdate reagent, insert a rubber stopper and shake for 5 minutes. Allow to stand on the steam bath for 30 minutes and then on the bench for 1 hr. Filter through an 11-cm. closely woven paper and wash the precipitate 15 to 20 times with hot acid-ammonium sulfate solution. Dissolve all adhering precipitate on the flask and on the paper with 25 ml. of NH_4OH (1:4) into a 150-ml. beaker, washing flask and paper with hot water. Add 40 ml. of H_2SO_4 (1:1) and pass the solution (Note 1) through a Jones reductor (Note 2), which has the outlet tube prolonged and reaching nearly to the bottom of the flask, dipping into 50 ml. of ferric alum solution. Follow this through the reductor with two 60-ml. portions of water. Titrate with the standard permanganate solution to a pink color that is permanent for 1 minute.

NOTE 1.—A blank determination should be made on corresponding amounts of acid and water, passing through the reductor into the usual amount of ferric alum solution in the flask.

NOTE 2.—During the reduction, care should be taken to adjust the speed of flow so that the "zone of reaction," which is clearly visible, should not extend beyond two-thirds of the distance down the reductor column.

Calculation

3. The percentage of phosphorus shall be calculated by means of the following formula:

$$\text{Phosphorus, per cent} = \frac{A \times B \times 100}{C}$$

where A = the number of milliliters of permanganate solution used;
B = the phosphorus value of solution; and
C = the weight of the sample.

TENTATIVE SPECIFICATIONS
FOR
ALUMINUM-BASE ALLOY DIE CASTINGS[1]

A.S.T.M. Designation: B 85 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931; REVISED, 1933.

Scope. 1. These specifications cover die castings die-cast from aluminum-base alloys. Seven alloy compositions are specified, designated alloys Nos. IV to IX, inclusive, and XII.

CHEMICAL COMPOSITION AND TESTS

Chemical Composition. 2. The alloys shall conform to the requirements as to chemical composition given in Table I within the limits specified therein.

3. (*a*) It is understood that iron contributes to the hardness in all these alloys. While the use of steel or iron containers for the commercial manufacture of die castings unavoidably introduces some of this element into the alloy, it shall not exceed the percentages specified in Table I.

(*b*) Manganese and nickel are not regarded as harmful elements in these alloys up to the limits specified in Table I.

Sampling. 4. Samples for chemical analysis may be taken either by sawing, drilling, or milling a representative group of castings, and shall represent the average cross-section of the material. The castings and cutter shall be thoroughly cleaned and no lubricant shall be used during the operations.

Chemical Analysis. 5. Chemical analysis shall be made in accordance with the Tentative Methods of Chemical Analysis of Aluminum and Light Aluminum Alloys (A.S.T.M. Designation: B 40 - 33 T) of the American Society for Testing Materials.[2]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. P. V. Faragher, Secretary of Committee B-6 on Die-Cast Metals and Alloys, Aluminum Co. of America, 2400 Oliver Building, Pittsburgh, Pa.

By adoption of these specifications, the American Society for Testing Materials does not undertake to insure any one utilizing such specifications against liability for infringement of any patent or assume any such liability, and such adoption does not constitute a recommendation of any patented or proprietary application that may be involved.

[2] See p. 620.

SOUNDNESS

Density. 6. No casting shall be acceptable which weighs less than a minimum agreed upon by the manufacturer and purchaser for the individual order.

WORKMANSHIP AND FINISH

Finish 7. Castings shall be produced with smooth surfaces, free from cracks and disfiguring blemishes.

TABLE I.—CHEMICAL COMPOSITIONS OF ALUMINUM-BASE DIE-CASTING ALLOYS.

Alloy[a]	Desired Composition per cent				Permissible Variations in Alloying Elements, per cent				Other Elements, Maximum, per cent					
	Copper	Silicon	Nickel	Aluminum	Copper	Silicon	Nickel	Aluminum	Iron	Zinc	Manganese	Magnesium	Tin	Total, Other Impurities
No. IV..	...	5	....	95	0.6 max.	4.5 to 6.0	0.5 max.	balance	2.0	0.75	0.3	0.1	0.1	0.2
No. V...	...	12	....	88	0.6 max.	11 to 13	0.5 max.	balance	2.0	0.75	0.3	0.1	0.1	0.2
No. VI.	2	3	....	95	1.5 to 2.5	2.5 to 3.5	0.5 max.	balance	2.5	0.75	0.3	0.1	0.1	0.2
No. VII.	4	5	....	91	3.5 to 4.5	4.5 to 5.5	0.5 max.	balance	2.25	0.75	0.3	0.1	0.1	0.2
No. VIII	1.5	1	2.25	95.25	1 to 2	0.75 to 2	1.75to2.5	balance	2.5	0.75	0.3	0.1	0.1	0.2
No. IX..	4	1.75	4	90.25	3.5 to 4.5	1.0 to 2.5	3.5 to 4.5	balance	2.5	0.75	0.3	0.1	0.1	0.2
No. XII.	8	1.5	....	90.50	6.0 to 8.0	3.5 max.	0.5 max.	balance	2.5	1.5	0.3	0.1	0.2	0.5

[a] The alloy designations correspond to numbers used in the investigation on aluminum-base die-casting alloys carried out under the jurisdiction of Committee B-6 on Die-Cast Metals and Alloys (formerly Subcommittee XV on Die-Cast Metals and Alloys of Committee B-2 on Non-Ferrous Metals and Alloys), the alloy numbers omitted correspond to alloy compositions which were investigated by the Committee, but which were not considered desirable of inclusion in these specifications. See *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 192 (1929).

Dimensions. 8. Dimensional tolerances shall be within the limits specified on the drawings describing the casting or castings on order, or shall be within the limits specified in the order.

REJECTION

Rejection. 9. Castings which show injurious defects subsequent to acceptance may be rejected. The manufacturer's liability shall be confined to replacing rejected castings without charge to the purchaser.

APPENDIX

The data in the following table do not constitute a part of these specifications. They will indicate to the purchaser the physical properties that may be expected of tension and impact test specimens when made in a die, the test specimens being cast in regular production routine and conforming to the chemical composition specified. It should be thoroughly understood that the following figures represent die-cast test specimens and not specimens cut from commercial die-cast parts. Rockwell hardness values have not been shown because they are considered too unreliable on die castings.

Alloy	Tension Tests on Round Specimens		Charpy Impact on Square Specimens, ft-lb.
	Tensile Strength, lb. per sq. in.	Elongation in 2 in., per cent	
No. IV	29 000	3.5	4.5
No. V	33 000	1.5	2.0
No. VI	30 000	3.5	5.0
No. VII	32 000	2.0	2.5
No. VIII	29 000	4.0	4.5
No. IX	31 000	1.5	2.0

TENTATIVE SPECIFICATIONS
FOR
ZINC-BASE ALLOY DIE CASTINGS[1]

A.S.T.M. Designation: B 86 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931; REVISED, 1933.

Scope

1. These specifications cover commercial die castings, die cast from zinc-base alloys. Two alloy compositions are specified, designated alloys Nos. XXI[2] and XXIII.

MANUFACTURE

Process

2. (*a*) The alloys may be made by any approved method.

(*b*) The casting shall be of uniform quality and no scrap shall be used other than the sprues, gates, rejected castings, etc., of the particular alloy, which are produced in the manufacturer's own plant. The rejected castings used shall be free from finishes, solder, or inserts which may contaminate the alloy.

Base Metal

3. The base metal for the alloys shall be slab zinc conforming to the requirements for the special high grade of the Standard Specifications for Slab Zinc (Spelter) (A.S.T.M. Designation: B 6) of the American Society for Testing Materials.[3]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. P. V. Faragher, Secretary of Committee B-6 on Die-Cast Metals and Alloys, Aluminum Co. of America, Pittsburgh, Pa.

By adoption of these specifications, the American Society for Testing Materials does not undertake to insure any one utilizing such specifications against liability for infringement of any patent or assume any such liability, and such adoption does not constitute a recommendation of any patented or proprietary application that may be involved.

[2] This alloy designation corresponds to the number used in the investigation on zinc-base die-casting alloys carried out under the jurisdiction of Committee B-6 on Die-Cast Metals and Alloys (formerly Subcommittee XV on Die-Cast Metals and Alloys of Committee B-2 on Non-Ferrous Metals and Alloys). See *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 192 (1929).

[3] 1933 Book of A.S.T.M. Standards, Part I, p. 858.

CHEMICAL COMPOSITION AND TESTS

Chemical Composition

4. The alloys shall conform to the following requirements as to chemical composition:

	ALLOY NO. XXI	ALLOY NO. XXIII
Copper, per cent	2.5 to 3.5	0.10, max.
Aluminum, per cent	3.5 to 4.5	3.5 to 4.5
Magnesium, per cent	0.02 to 0.10	0.03 to 0.08
Iron, max., per cent	0.100	0.100
Lead, max., per cent	0.007	0.007
Cadmium, max., per cent	0.005	0.005
Tin, max., per cent	0.005	0.005
Zinc, per cent	remainder	remainder

Sampling

5. (*a*) The sample for chemical analysis may be taken either by sawing, drilling, or milling the casting or tension test specimen, and shall represent the average cross-section of the piece.

(*b*) The saw, drill, cutter or other tool used shall be thoroughly cleaned. No lubricant shall be used in the operation, and the sawings or metal chips shall be carefully treated with a magnet to remove any particles of iron introduced in taking the sample.

PHYSICAL PROPERTIES AND TESTS

Expansion

6. (*a*) The average expansion of any five or more castings or test specimens after being exposed to water vapor at 95 C. for 10 days shall not exceed the following values:

	ALLOY NO. XXI	ALLOY NO. XXIII
Expansion per inch, max., in	0.0025	0.0010

NOTE.—A maximum expansion of the amount permitted in 1 in. is allowable in any dimension less than 1 in. Dimensions shall be measured across solid sections of the casting.

(*b*) The humidity cabinet shall be vented, and shall contain no wood or organic matter. The specimens shall be supported at points outside of the test section by glass, porcelain, zinc, or zinc-coated metal.

Optional Tests

7. Unless specified in the order or specifically guaranteed by the manufacturer, acceptance of castings under these specifications shall not depend on physical properties determined by tension or impact tests.

Physical Properties

8. When specified, the test specimens representing the alloy shall conform to the following requirements as to physical properties in the condition as received from the manufacturer:

	AVERAGE OF FIVE SPECIMENS		INDIVIDUAL SPECIMENS	
	ALLOY No. XXI	ALLOY No. XXIII	ALLOY No. XXI	ALLOY No. XXIII
Tensile strength, min., lb. per sq. in.	44 000	35 000	35 000	30 000
Elongation in 2 in., min., per cent	2.0	3.0	0.5	2.0
Charpy impact, min., ft-lb	6.0	12.0	4.0	8.0

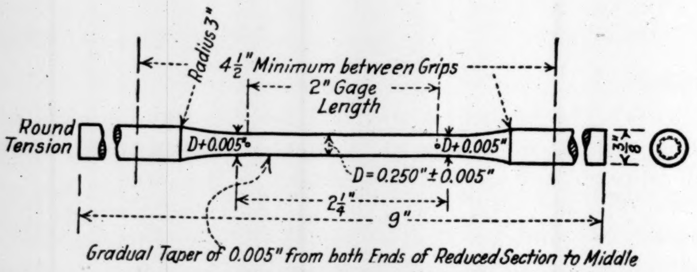
Radius 3"
4½" Minimum between Grips
2" Gage Length
Round Tension
D+0.005"
D+0.005"
D=0.250"±0.005"
3/8"
2¼"
9"
Gradual Taper of 0.005" from both Ends of Reduced Section to Middle

FIG. 1.—Round Tension Test Specimen.

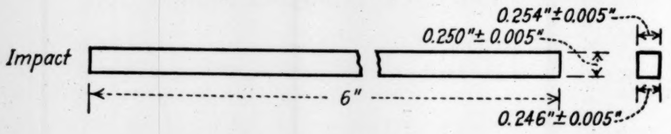
Impact
0.254"±0.005"
0.250"± 0.005"
6"
0.246"±0.005"

FIG. 2.—Charpy Impact Test Specimen.

Stability

9. When specified, the test specimens representing the alloy shall conform to the following requirements as to physical properties after being exposed to water vapor at 95 C. for 10 days as specified in Section 6.

	AVERAGE OF FIVE SPECIMENS	
	ALLOY No. XXI	ALLOY No. XXIII
Tensile strength, min., lb. per sq. in.	30 000	30 000
Elongation in 2 in., min., per cent	0.5	1.5
Charpy impact, min., ft-lb	0.75	12.0

Test Specimens

10. (*a*) The test specimens shall be die cast according to the dimensions shown in Figs. 1 and 2 and shall be tested without machining. No ejector pins shall be used on reduced sections. Specimens shall be removed from dies as soon as cast and cooled in still air with gates attached.

Defective Bars

(*b*) Impact test specimens shall be made by cutting the 6-in. bar into two pieces 3 in. in length. The anvil of the testing machine shall have a 40-mm. span. The larger width of the test specimen shall be placed against the anvil.

(*c*) In case any of the test specimens contain a flaw or flaws which results in failure of the alloy to meet the specifications, the manufacturer and purchaser shall agree upon the selection of specimens for retests, or the defective bars shall be disregarded.

Number of Tests

11. Five of each type of test specimen shall be tested.

Soundness

12. Heavy section die castings are subject to spongy centers. The extent of this sponginess if objectionable shall be mutually agreed upon by the manufacturer and purchaser for each individual casting.

WORKMANSHIP AND FINISH

Finish

13. The die casting shall be produced free from cracks and other disfiguring blemishes.

REJECTION

Rejection

14. Die castings which show injurious defects revealed by machining operations subsequent to acceptance may be rejected, and if rejected the manufacturer's responsibility shall be limited to replacing rejected parts without charge to the purchaser.

TENTATIVE METHODS OF CHEMICAL ANALYSIS OF METALLIC MATERIALS FOR ELECTRICAL HEATING[1]

A.S.T.M. Designation: B 71 – 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1927; REVISED, 1928, 1929, 1933.[2]

DETERMINATION OF NICKEL

SOLUTIONS REQUIRED

1. The following reagents will be required:

Concentrated Sulfuric Acid (sp. gr. 1.84).

Concentrated Nitric Acid (sp. gr. 1.42).

Concentrated Hydrochloric Acid (sp. gr. 1.19).

Dilute Sulfuric Acid (1:1).—Slowly stir 100 ml. of H_2SO_4 (sp. gr. 1.84) into 100 ml. of water.

Dilute Sulfuric Acid (1:99).—Slowly stir 10 ml. of H_2SO_4 (sp. gr. 1.84) into 990 ml. of water.

Tartaric Acid (20 per cent).

Ammonium Hydroxide (sp. gr. 0.90).

Dilute Acetic Acid (1:3).—Mix 1 ml. of acetic acid (sp. gr. 1.04) and 3 ml. of water.

Dilute Nitric Acid (1:3).—Mix 100 ml. of HNO_3 (sp. gr. 1.42) and 300 ml. of water.

Nitro-Hydrochloric Acid.—Mix 10 ml. of HNO_3 (sp. gr. 1.42), 30 ml. of HCl (sp. gr. 1.19) and 40 ml. of water.

Sodium Dimethylglyoxime.—Dissolve 3 g. of dimethylglyoxime in 100 ml. of NaOH (3 per cent), made fresh each time used.

Potassium Thiocarbonate.—Saturate with H_2S one half of 250 ml. of a 5 per cent solution of KOH, add the other half and heat moderately with one twenty-fifth of its volume of CS_2. Decant the dark red liquid from the undissolved CS_2 and preserve in a well closed flask.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. F. E. Bash, Secretary of Committee B-4 on Electrical-Heating, Electrical-Resistance and Electric-Furnace Alloys, Driver-Harris Co., Harrison, N. J.

[2] Latest revision accepted by Committee E-10 on Standards, March 8, 1933.

METHOD

2. (*a*) Dissolve exactly 1 g. of the alloy sample in 20 ml. of nitrohydrochloric acid in a covered 600-ml. beaker. Add 20 ml. of dilute H_2SO_4 (1:1) and evaporate the liquid carefully to fumes of sulfur trioxide. When the beaker and its contents have cooled, add 100 ml. of water and allow the solution to digest at a low heat until all salts have dissolved. Filter the solution on a 9-cm. paper to remove any silica and wash the paper and residue thoroughly with hot water or, if an insoluble residue is present, wash with dilute H_2SO_4 (1:99). Ignite the precipitate at a low heat and treat with 2 ml. of HF and several drops of H_2SO_4 (1:1) in a platinum crucible, and evaporate to dryness. Fuse the residue with a little sodium carbonate, dissolve in HCl and add to the main nickel solution.

Transfer the nickel solution to a 250-ml. graduated flask and dilute to the mark with cold water. Mix and draw off exactly 50 ml. by means of an accurately calibrated pipette, and transfer this aliquot portion to a 600-ml. beaker. This aliquot portion represents 0.2 g. of the original sample. Add 250 ml. of cold water and 25 ml. of a 20 per cent solution of tartaric acid (enough to hold all the iron and chromium in solution), make the solution alkaline with NH_4OH, and then make it acid with an excess of 15 ml. of HCl (sp. gr. 1.19). Add 20 ml. (for the 60 per cent nickel alloy) to 30 ml. (for the 80 per cent nickel alloy) of a freshly prepared solution of sodium dimethylglyoxime, and make the solution ammoniacal, and then make it just acid with dilute acetic acid (1:3). Stir the solution vigorously and allow it to stand at a temperature of from 75 to 90° C. with occasional stirring for 30 minutes. If an alcoholic solution of dimethylglyoxime is used to precipitate the nickel, digest the contents of the beaker at a temperature just short of the boiling point until the odor of alcohol can no longer be detected. From 65 to 100 ml. of a 1 per cent alcoholic solution of dimethylglyoxime will be required.

Filter the scarlet precipitate of nickel dimethylglyoxime on a tared Gooch crucible. Wash thoroughly with hot water and dry at from 105 to 110° C. to constant weight. Cool in a desiccator and weigh.

Calculation.—The weight of nickel dimethylglyoxime multiplied by 20.32 and again by 5 gives the percentage of nickel in the sample. Treat the filtrate with 10 ml. of HCl (sp. gr. 1.19) and approximately 5 ml. of sodium dimethylglyoxime and again adjust with ammonia and acetic acid as previously described in order to make certain of the complete precipitation of the nickel. This method yields results that are correct to within ±0.35 per cent.

(*b*) If greater accuracy is desired, use a larger aliquot portion with proportionally larger amounts of reagents, filter the nickel dimethylglyoxime precipitate on a 15-cm. paper and wash thoroughly eighteen or twenty times with hot water. Dissolve the precipitate off the paper with boiling dilute HNO_3 (1:3) and wash the filter thoroughly with hot water. Add 10 ml. of dilute H_2SO_4 (1:1) and boil the liquid gently until strong fumes of sulfur trioxide are evolved. Having allowed the beaker and its contents to cool somewhat, add 10 ml. of HNO_3 (sp. gr. 1.42) and repeat the evaporation. Rinse the cover and sides of the beaker with a fine jet of water and fume the solution again to insure the expulsion of every trace of the HNO_3. When cool, add approximately 50 ml. of cold water and boil the contents of the beaker for several minutes, which should result in a perfectly clear solution.

Neutralize with NH_4OH and add an excess of 25 ml. of NH_4OH (sp. gr. 0.90). Now electrolyze the nickel sulfate solution with a current of from 1 to 2 amperes, using a weighed platinum gauze cathode and a spiral platinum anode. Continue the electrolysis until the solution has become colorless and then continue for at least 15 minutes longer. Now test the solution by adding one or two drops of it to a solution of potassium thiocarbonate. A pink or red color indicates the presence of nickel. The amount of the solution withdrawn for this test will not affect the results and may be neglected. This test will show whether or not the electrolysis has been completed. Wash the metal deposited on the cathode with water while the current is flowing. Remove the cathode and dip it first into a beaker of distilled water and then into absolute alcohol, dry for a few minutes at a temperature of from 80 to 100° C., and weigh.

Calculation.—The increase in weight of the cathode multiplied by 100 and divided by the weight of the sample taken gives the percentage of nickel in the sample. In the case of very accurate work, dissolve the deposit off the cathode with warm HNO_3 (sp. gr. 1.42), wash the cathode with water, then alcohol, dry for a few minutes at 80° C. and reweigh.

DETERMINATION OF CHROMIUM
BY THE
PERSULFATE METHOD

SOLUTIONS REQUIRED

3. The following reagents will be required:

Silver Nitrate Solution (0.5 per cent).—Dissolve 5 g. of $AgNO_3$ in 1000 ml. of water.

Ammonium Persulfate.

Phosphoric Acid (sp. gr. 1.72).

Potassium Permanganate (2.5 per cent).

Sodium Chloride (10 per cent).—Dissolve 100 g. of NaCl in 1000 ml. of water.

Perchloric Acid (60 per cent).

Sulfuric Acid (1:1).—Slowly stir 500 ml. of H_2SO_4 (sp. gr. 1.84) into 500 ml. of water.

Nitric Acid (sp. gr. 1.42).

Standard Ferrous Ammonium Sulfate Solution.—Dissolve 39.25 g. of ferrous ammonium sulfate in distilled water, containing 20 ml. of dilute H_2SO_4 (1:1). Dilute to 1 liter, mix thoroughly and standardize against 0.1 *N* potassium permanganate, which has in turn been standardized against the U. S. Bureau of Standards sodium oxalate. This solution should be standardized just before using, as its value may change from day to day. One cubic centimeter of 0.1 *N* solution is equivalent to 0.001733 g. of chromium.

Standard Potassium Permanganate Solution (0.1 N).—Dissolve approximately 3.18 g. of pure potassium permanganate in 300 ml. of hot distilled water, boil for 10 or 15 minutes, cool to room temperature and filter on asbestos. Transfer the solution to a glass-stoppered bottle and allow it to stand for two weeks, at the end of which time filter again on asbestos and transfer to a liter flask and dilute to the mark. This solution should be kept in a dark bottle. After a preliminary standardization against the U. S. Bureau of Standards sodium oxalate, dilute so as to be exactly 0.1 *N*, and verify this strength by a second comparison with sodium oxalate.

METHOD

4. Treat 1 g. of the sample in a covered 600-ml. beaker with 10 ml. of perchloric acid (60 per cent). Heat to strong fumes of perchloric acid to aid in the solution of the alloy, and continue the heating for 3 or 4 minutes after the alloy has dissolved completely to insure the oxidation of the larger part of the chromium to the sexivalent state. Add 100 ml. of hot water and heat to boiling for several minutes to expel chlorine. Remove from the plate and add 20 ml. of dilute H_2SO_4 (1:1) and 5 ml. of HNO_3 (sp. gr. 1.42). Dilute to 250 ml. with hot water, add 10 ml. of $AgNO_3$ (0.5 per cent), 3 g. of ammonium persulfate and 5 or 6 drops of $KMnO_4$ solution (2.5 per cent). Boil for 5 minutes or longer, add 20 ml. of NaCl solution (10 per cent) and boil for 10 minutes after the permanganic acid or any manganese dioxide formed has dissolved completely, in order to

make sure that all chlorine has been expelled. Cool to room temperature and dilute with cold water to 400 ml. Treat with 2 ml. of H_3PO_4 (sp. gr. 1.72), add from a burette standardized ferrous ammonium sulfate until the solution turns green, and then add 5 ml. in excess. Titrate this excess back with 0.1 N potassium permanganate.

5. *Calculation.*—Calculate the percentage of chromium from the following formula:

$$\text{Percentage of chromium} = \frac{[(A \times B) - C] \times 0.001733}{\text{weight of sample}} \times 100$$

where A = the volume in cubic centimeters of ferrous ammonium sulfate used;

B = the normality factor of ferrous ammonium sulfate, determined daily;

C = the volume in cubic centimeters of exactly 0.1 N potassium permanganate used.

DETERMINATION OF IRON

SOLUTIONS REQUIRED

6. The following reagents will be required:

Perchloric Acid (60 per cent).

Dilute Hydrochloric Acid (1:4).—Mix 25 ml. of HCl (sp. gr. 1.19) and 100 ml. of water.

Ammonium Hydroxide (sp. gr. 0.90).

Ammonium Persulfate.

Stannous Chloride Solution.—Dissolve 50 g. of stannous chloride in 100 ml. of HCl (sp. gr. 1.19) and dilute to 1000 ml.

METHOD

7. For alloys containing 10 per cent or more of iron, use a 1-g. sample, and for alloys containing 2 per cent or less of iron, use a 3-g. sample. Treat the sample in a 500-ml. Erlenmeyer flask fitted with a Meyer bulb or trap with 20 to 50 ml. of perchloric acid (60 per cent) at a temperature of 203° C. or higher until the alloy has dissolved completely, and continue the boiling of the acid for five minutes longer to aid in the complete oxidation of the chromium to the sexivalent state. The tall flask and bulb (or trap) are used to prevent the loss of $FeCl_3$ by volatilization, which happens if a covered beaker is used. Add approximately 200 ml. of hot water, an excess of about 10 ml. of NH_4OH (sp. gr. 0.90) and 5 g. of ammonium persulfate. Boil for 5 minutes, filter and wash thoroughly with hot

water. Dissolve the $Fe(OH)_3$ in hot HCl (1:4) and repeat the precipitation with NH_4OH and ammonium persulfate, and the filtration. Dissolve the iron precipitate in the least possible amount (15 to 25 ml.) of boiling, dilute HCl (1:4) and wash the filter thoroughly with water. Heat to boiling, add stannous chloride solution slowly and with stirring to discharge the yellow color of the ferric chloride and to provide a few drops in excess. Finish the determination by the Zimmerman-Reinhardt method.[1]

DETERMINATION OF MANGANESE

SOLUTIONS REQUIRED

8. The following reagents will be required:

Perchloric Acid (60 per cent).

Nitric Acid (sp. gr. 1.135).

Nitric Acid (3 per cent).—Mix 3 ml. of HNO_3 (sp. gr. 1.42) and 100 ml. of water.

Ammonium Hydroxide (sp. gr. 0.90).

Ammonium Persulfate.

Sodium Bismuthate.

Sulfurous Acid.

Standard Ferrous Ammonium Sulfate Solution.—Prepare as described in Section 3 under the Determination of Chromium by the Persulfate Method. One cubic centimeter of 0.1 *N* solution is equivalent to 0.001099 g. manganese.

Standard Potassium Permanganate Solution (0.1 N).—Prepare as described in Section 3 under the Determination of Chromium by the Persulfate Method.

METHOD

9. Treat exactly 1 g. of the sample in a covered 600-ml. beaker with 20 ml. of perchloric acid (60 per cent) at a temperature of 203° C. or higher until the alloy has dissolved completely, and continue the boiling of the acid for 5 minutes longer to completely oxidize the chromium. Add 200 ml. of warm water, an excess of about 10 ml. of NH_4OH (sp. gr. 0.90) and 5 g. of ammonium persulfate. Boil for 5 minutes, filter on two superimposed 11-cm. filter papers, supported on a Büchner funnel, gentle suction being employed. Wash the precipitate thoroughly with hot water. Dissolve the precipitate of ferric hydroxide and manganese peroxide in 75 ml. of hot HNO_3 (sp. gr. 1.135) and a few drops of sulfurous acid. Wash the filter thoroughly with hot water. Repeat the precipitation with NH_4OH and ammonium persulfate, and the filtration. Dissolve the pre-

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[1] A. A. Blair, "The Chemical Analysis of Iron," Vol. 8, p. 248.

cipitate in 50 ml. of hot HNO_3 (sp. gr. 1.135) and a few drops of sulfurous acid, and wash the filter with HNO_3 of the same strength. Transfer to a 300-ml. Erlenmeyer flask and boil for several minutes to expel oxides of nitrogen. Treat cautiously with 0.5 g. of sodium bismuthate and heat to boiling for 1 or 2 minutes. Clear with a sufficient excess of sulfurous acid and boil for 2 or 3 minutes longer. Cool to 15° C., add 1 to 2 g. of sodium bismuthate, shake vigorously for 1 minute, dilute with an equal volume of cold water and filter at once on an ignited asbestos or alundum filter. Wash with cold 3 per cent HNO_3. Add from a burette 20 to 35 ml. (depending on the amount of permanganic acid) of ferrous ammonium sulfate solution and titrate the excess with standard $KMnO_4$ solution.

10. *Calculation.*—Calculate the percentage of manganese from the following formula:

$$\text{Percentage of manganese} = \frac{[(A \times B) - C] \times 0.001099}{\text{weight of sample}} \times 100$$

where A = the volume in cubic centimeters of ferrous ammonium sulfate used;

B = the normality factor of ferrous ammonium sulfate, determined daily;

C = the volume in cubic centimeters of exactly 0.1 N potassium permanganate used.

DETERMINATION OF CARBON
BY THE
DIRECT COMBUSTION METHOD

Direct combustion of these alloys in oxygen at approximately 1100° C. yields only part of the total carbon. To effect complete oxidation of the carbon the sample must, previous to ignition in oxygen, be mixed with some oxidizing agent or accelerator. Many materials have been proposed and are used for this purpose, among which may be mentioned iron, steel or tin filings of low-carbon content. The evolved carbon dioxide is absorbed in ascarite (asbestos impregnated with sodium hydroxide) and weighed. Reference should be made to the Determination of Carbon by the Direct-Combustion Method, as described in the Standard Methods of Chemical Analysis of Plain Carbon Steel (A.S.T.M. Designation: A 33) of the American Society for Testing Materials.[1]

SAMPLE

11. The sample shall consist of at least ten factor weights (one factor weight equals 0.2727 g.) and shall be rather finely divided in order that such a large sample may be placed in the combustion boat. In case the carbon exceeds 0.05 per cent, a five factor weight sample

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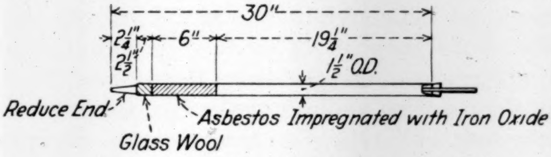
[1] 1933 Book of A.S.T.M. Standards, Part I, p. 326.

shall be used. Care must be taken in placing the sample in the trench, as its proper distribution is of considerable importance. With all samples, close packing in a small space is conducive to rapid and complete combustion. The usual precautions shall be used in obtaining a perfectly clean sample.

APPARATUS

12. (*a*) *Boats and Lining Material.*—Zirkite boats 4 in. long by ¾ in. wide by ⅜ in. deep (inside dimensions) are the most satisfactory, although alundum, nickel, or porcelain boats may be used. The boats shall be ignited in a muffle furnace before using. The bottom of the boat shall be lined with a trench of 90-mesh RR alundum which is especially prepared for carbon determinations. The sample shall be covered with a very thin layer of alundum. Some alundum powder shall be sprinkled inside of the combustion tube to prevent the boat from sticking.


30"
2¼"
6"
19¼"
2½"
1½" O.D.
Reduce End
Glass Wool
Asbestos Impregnated with Iron Oxide

Detail of Tube F

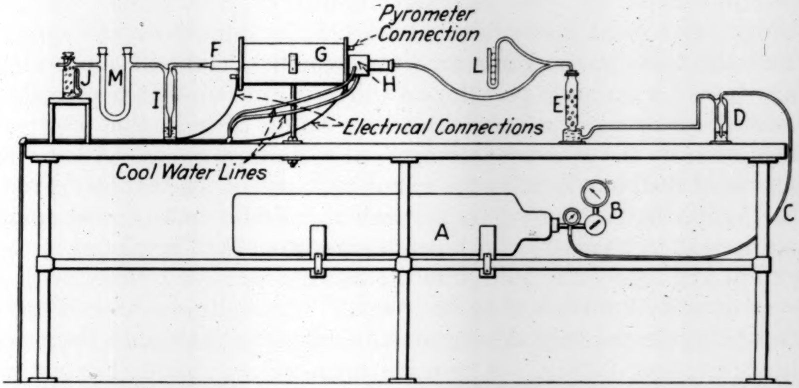

Pyrometer Connection
F
G
H
J
M
I
L
E
D
Electrical Connections
Cool Water Lines
A
B
C

FIG. 1.—Apparatus for the Determination of Carbon by the Combustion Method.

(*b*) *Flux.*—Exactly 2 g. (or a weight equal to that of the sample) of fine drillings of ingot iron or tin filings of known carbon content shall be sprinkled over the sample before the alundum is placed over the top of the whole charge.

(*c*) *Furnace and Combustion Tube.*—The standard electric combustion furnace in common use may be used, but as the temperatures are considerably higher the life of the heating element will be shorter than usual. A pyrometer shall always be used. A fused-silica or porcelain tube 30 in. in length and 1½ in. in diameter gives the best results. The front end of the tube shall be encased in a water-cooled jacket. The rear or reduced end of the tube shall be packed with glass wool for a length of 2½ in. and then with asbestos impregnated with ferric oxide (prepared by saturating the asbestos with a solution of ferric nitrate and igniting overnight at 1000° C. or higher) for a length of about 6 in. Ferric oxide will serve to oxidize any carbon monoxide formed and will convert any sulfur dioxide to ferric sulfate.

(*d*) *Detailed Description of Apparatus.*—Figure 1 illustrates the details of the apparatus. Oxygen from the 100 cu. ft. cylinder *A* passes through the reducing valve *B* to the H_2SO_4 (sp. gr. 1.84) bottle *D*, thence to the soda lime tube *E* to the furnace. From the furnace the gases pass through the tower *I* which is filled with H_2SO_4 (sp. gr. 1.84) to a depth of 2½ in. to remove moisture. The H_2SO_4 must be changed at regular intervals of about ten days under normal usage. From the tower *I* the gases pass through the U-tube *M* filled with anhydrone (magnesium perchlorate trihydrate) to insure the complete removal of all moisture and also any sulfur trioxide that escaped absorption by the asbestos impregnated with ferric oxide. A layer of glass wool shall be placed in the top of each arm of the U-tube. From the U-tube *M*, the gases pass through the Nesbit bulb *J* containing ascarite (12 to 30-mesh). A layer of glass wool shall be placed in the bottom and top of the bulb, and the ascarite shall be covered with a layer of anhydrone about ½ in. thick. The bulb, tower, and tube shall be connected very closely so as to minimize passage of the gases through rubber tubing. A mercury manometer *L* which has a 6-in. scale with ¼-in. subdivisions shall be used for indicating the pressure, and, when calibrated, the rate of flow of the oxygen. The manometer shall be calibrated by measuring the oxygen passing through the train at a given pressure, either by metering or collecting over water. The rate of flow of the oxygen shall be held at 400 to 600 ml. per minute, after combustion of the sample.

METHOD

13. The furnace shall be heated to approximately 1100° C.; a sample of low-carbon steel is then burned in oxygen and the evolved carbon dioxide absorbed in the ascarite bulb, *J*. Weigh the ascarite bulb and connect it as shown in Fig. 1, quickly insert the boat (con-

taining the sample), by means of a copper rod, into the hottest part of the furnace and immediately replace the stopper. Allow the boat and its contents to heat for about one minute with no oxygen passing; this will result in some oxygen being absorbed by the iron, and the H_2SO_4 in the tower *I* will be drawn back into the large bulb as a consequence of the partial vacuum resulting therefrom. At the expiration of about 1 minute, admit oxygen to the tube at such a rate that the manometer will show a difference in level of $1\frac{1}{2}$ in. This should cause the iron to burn with vivid incandescence and result in complete combustion of the iron in the alloy in from $1\frac{1}{2}$ to 2 minutes. During the burning of the sample the mercury manometer shall be held at a difference in level of $1\frac{1}{2}$ in. and so maintained to the end of the operation. The pressure corresponds, normally, to an oxygen flow of 400 to 600 ml. per minute. Should varying resistance in the train change this ratio, a higher or lower pressure shall be maintained so as to give approximately the same flow of oxygen. The preliminary heating followed by the rapid admission of oxygen is absolutely essential to securing complete combustion. Only in case the oxides are so thoroughly fused as to show no trace of the shape of the original drillings when the boat is removed from the furnace, shall the combustion be considered successful.

At the conclusion of the above described operations (6 minutes after the boat was inserted into the furnace), close the stopper in *J* and remove the absorption bottle, cool for about 1 minute and weigh. The stopper is loosened for relief of vacuum for a second or so just before the completion of the weighing. In weighing the absorption bottle, a similar bottle filled with ascarite, but weighing slightly less, is used for a counterpoise. The counterpoise bottle is always kept close to the absorption bottle so as to be exposed to exactly the same conditions of humidity, temperature, etc.

Run a blank on the ingot iron, boat, etc., and deduct any carbon so found from that obtained in the analysis.

Allowable Error.—Percentages of carbon determined by the above method should be accurate to ±0.01 per cent. If greater accuracy is desired, the combustion shall be conducted at a temperature of from 1150 to 1200° C. or even higher.

DETERMINATION OF INSOLUBLE RESIDUE

METHOD

14. The sample should weigh at least 5 g. and if the alloy is known to be low in insoluble residue a 10-g. sample should be used. Treat the sample with from 200 to 400 ml. of HCl (sp. gr. 1.19) at a

temperature of from 60 to 70° C. until the reaction appears to be complete, then add 1 to 2 ml. of HNO_3 (sp. gr. 1.42). Boil the solution for about 2 minutes, dilute with an equal volume of hot water, filter, and wash the filter thoroughly with hot dilute HCl (5:95).

Ignite the residue at a low heat in a platinum crucible, treat with HF and several drops of dilute H_2SO_4 (1:1), and evaporate the solution just to fumes of sulfur trioxide. If any residue remains, add 10 ml. of water to the crucible, filter on a 9-cm. paper and wash the residue with hot water. Ignite any residue remaining on the paper and weigh.

15. *Calculation.*—The increase in weight multiplied by 100 and divided by the weight of sample taken gives the percentage of insoluble residue.

Accuracy.—In the case of an insoluble residue of 0.05 per cent, duplicate determinations should check within ±0.02 per cent insoluble residue.

DETERMINATION OF SILICON

METHOD

16. Treat a two to five factor weight sample (one factor weight equals 0.4672 g.) in a covered 300-ml. porcelain casserole with 15 to 35 ml. of perchloric acid (60 per cent) at a temperature of 203° C. (the boiling point of the acid) until the alloy has dissolved completely, and continue the boiling for 10 minutes longer. Add 100 ml. of warm water, boil for several minutes and filter on an 11-cm. paper of close texture. Wash six or eight times with hot water, once with sulfurous acid (10 per cent) to reduce any chromic acid held in the filter, and then thoroughly with hot water.

Ignite the paper and precipitate in a small platinum crucible, first at a dull red heat until the carbon of the filter paper has been oxidized, and finally at 1050 to 1100° C. Allow the crucible to cool in a desiccator and weigh. Add one or two drops of H_2SO_4 (1:1), several milliliters of HF, and evaporate the solution until all the H_2SO_4 has been expelled. Ignite the crucible again at 1050 to 1100° C., cool and weigh.

17. *Calculation.*—The difference between the first and the second weights multiplied by 100 and divided by the weight of sample taken gives the percentage of silicon in the sample.

DETERMINATION OF SULFUR
BY THE
EVOLUTION-TITRATION METHOD

This method is based on (1) the evolution of practically all the sulfur in the alloy as hydrogen sulfide when the alloy is dissolved in HCl (sp. gr. 1.19) (see Note); (2) absorption of the evolved gas by means of an ammoniacal solution of cadmium chloride; and (3) determination of the sulfur by titration with a standard solution of potassium iodate (0.0312 *N*).

SOLUTIONS REQUIRED

18. The following reagents will be required:

Potassium Permanganate Solution (2.5 per cent).—Dissolve 2.5 g. of $KMnO_4$ in 100 ml. of water.

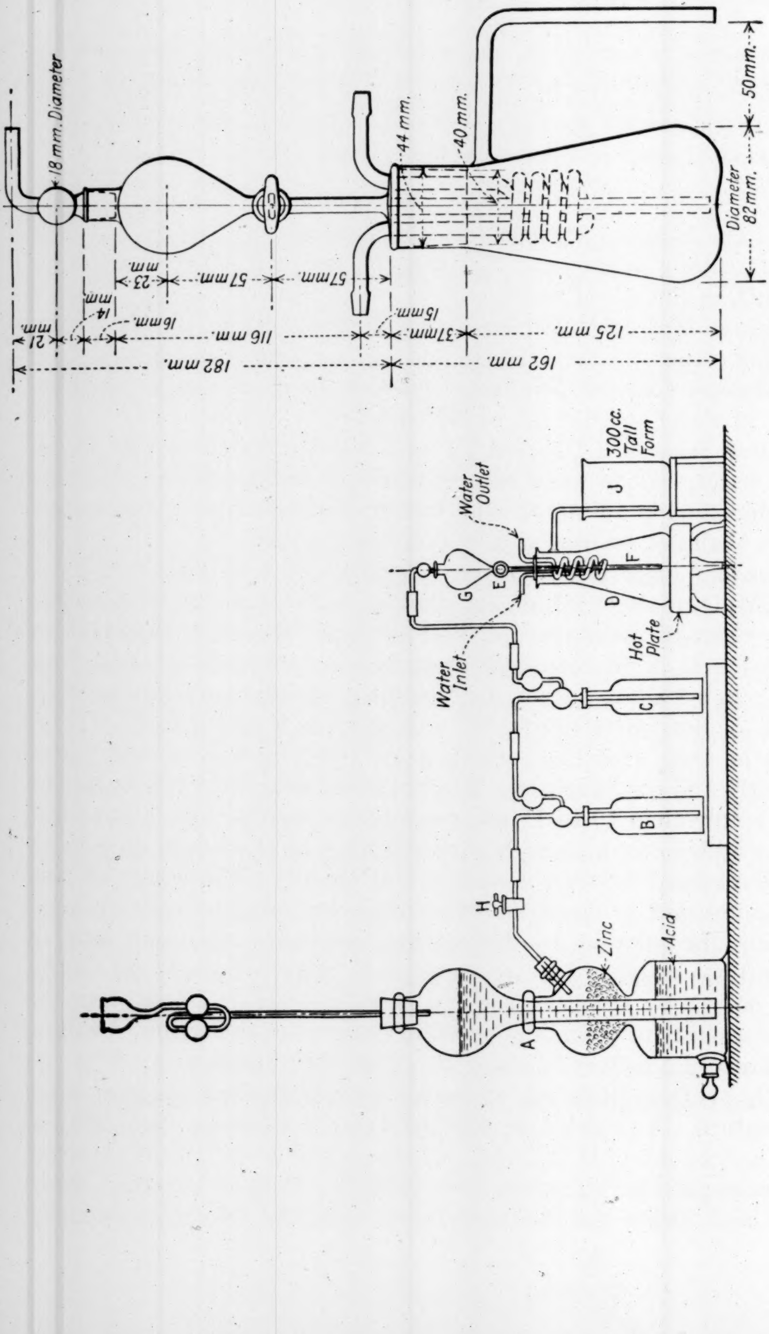
Sodium Hydroxide (30 per cent).—Dissolve 30 g. of NaOH in 100 ml. of water.

Cadmium Chloride Solution.—Dissolve 10 g. of $CdCl_2 \cdot 2H_2O$ in 400 ml. of water and 600 ml. of NH_4OH (sp. gr. 0.90).

Starch Solution.—Dissolve 1.2 g. of soluble starch in 100 ml. of boiling water, cool to room temperature and add a solution of 0.5 g. of KI dissolved in 10 ml. of cold, freshly distilled water. The starch solution shall not be used if it is over one day old.

Standard Potassium Permanganate (0.03 N).—Dissolve 0.99 g. of pure $KMnO_4$ in 1000 ml. of hot distilled water, boil for 10 minutes, cool to room temperature and filter through asbestos. Standardize against the U. S. Bureau of Standards standard sodium oxalate as follows: In a 200-ml. beaker, dissolve 0.1 g. of sodium oxalate in 75 to 100 ml. of hot water (80 to 90° C.) and add 4 ml. of H_2SO_4 (1:1). Titrate at once with the permanganate solution, stirring the liquid vigorously and continuously. The permanganate must not be added more rapidly than 10 to 15 ml. per minute, and the last 0.5 to 1 ml. must be added dropwise, with particular care to allow each drop to be fully decolorized before the next is introduced. The excess of permanganate used to cause an end-point color must be estimated by matching the color in another beaker containing the same bulk of acid and hot water. The temperature of the solution should not be below 60° C. by the time the end point is reached. Calculate the exact normality of potassium permanganate from the sodium oxalate.

Standard Sodium Thiosulfate (0.03 N).—Dissolve 7.5 g. of $Na_2S_2O_3 \cdot 5H_2O$ in 1000 ml. of freshly boiled, distilled water at room temperature. To 250 ml. of distilled water in a 500-ml. flask add 1 g. of KI and 10 ml. of HCl (1:1). Cool and add 35 ml. of the standard potassium permanganate solution (0.03 *N*) from a burette. Swirl gently and titrate the liberated iodine with the thiosulfate solution


A
Zinc
Acid
H
B
C
Water Inlet
G
E
D
F
Hot Plate
Water Outlet
J
300 cc. Tall Form
18 mm. Diameter
44 mm.
40 mm.
50 mm.
Diameter 82 mm.
21 mm.
14 mm.
16 mm.
23 mm.
57 mm.
57 mm.
116 mm.
15 mm.
37 mm.
125 mm.
182 mm.
162 mm.

Decomposition Flask, Pulsifer Design.

FIG. 2.—Apparatus for Determination of Sulfur by the Evolution-Titration Method.

to a light straw color. Add several milliliters of the freshly prepared starch solution and continue the titration to the disappearance of the blue color. Calculate the normality of the thiosulfate solution from the standard permanganate solution.

Standard Potassium Iodate (0.0312 N).—Dissolve 1.12 g. of pure KIO_3, and 12 g. of KI in 1000 ml. of distilled water. To 250 ml. of cold distilled water in a 500-ml. flask, add 10 ml. of HCl (1:1) and then as the flask is gently swirled, add 35 ml. of the iodate solution from a burette. Titrate the liberated iodine with the standard sodium thiosulfate solution (0.03 *N*) to a light straw color, add several milliliters of the freshly prepared starch solution and continue titration to the disappearance of the blue color. Calculate the normality of the iodate solution and adjust the solution so that 1 ml. is equivalent to 0.0005 g. of sulfur.

APPARATUS

19. Figure 2 illustrates the details of the apparatus employed. Hydrogen supplied from the Kipp generator, *A*, is freed from any sulfur by passage through a solution of potassium permanganate (2.5 per cent) contained in a Drechsel bottle, *B*, and sodium hydroxide (30 per cent) held in the Drechsel bottle, *C*. Hydrogen is admitted through a glass stopcock, *E*, to the decomposition flask, *D*. The decomposition flask (Pulsifer's design) is provided with a ground-glass stopper, *E*, a funnel, *G*, and a cooling coil, *F*, with inlet and outlet tubes. An ammoniacal solution of cadmium chloride or some other suitable absorbent is held in a 300-ml. beaker, *J*. The absorption should not be carried on in direct sunlight.

NOTE.—It is advisable to use an all-glass apparatus because the length of time (30 minutes) required for the solution of the alloy gives opportunity for fumes of hydrochloric acid to attack rubber stoppers and rubber hose connections, which always contain sulfur, and thus cause erroneous results.

METHOD

20. Transfer to the decomposition flask 5.00 g. of the alloy ribbon which has been cut into very small pieces or of the wire sample which has been flattened by means of a hammer and cut into small pieces. Pass a stream of hydrogen from the Kipp generator through the apparatus to displace the air. Pour 25 ml. of cadmium chloride solution into the beaker, *J*, and add sufficient water to give a depth of 3 in. of the solution. Stop the hydrogen by closing the control stopcock, *H*, on the Kipp generator. Close the stopcock *E*. Remove the ground-glass tube leading into the funnel, *G*, and introduce 100 ml. of HCl (sp. gr. 1.19) (see Note) into the decomposition flask through

the funnel. As soon as the acid has been added, replace the ground-glass inlet tube, open the stopcock, *E*, and pass a steady stream of hydrogen through the apparatus during the remainder of the determination. Apply sufficient heat to the decomposition flask to maintain a steady decomposition of the sample. Passage of a stream of cold water through the cooling coil, *F*, of the decomposition flask serves to cool the stopper and to aid in maintaining the strength of the acid in the flask. Thirty minutes of this treatment is ordinarily sufficient to cause complete decomposition. When there is no further action, boil the solution in the decomposition flask for several minutes and continue the stream of hydrogen for 5 minutes longer.

At the end of this time remove the absorption beaker, *J*, close stopcock, *E*, and the control stopcock, *H*, and discontinue heating the decomposition flask. Filter the cadmium chloride solution through an 11-cm. filter paper and wash the precipitate several times with water. Return the paper and precipitate to a 600-ml. beaker, add 300 ml. of cold water and 40 ml. of dilute HCl (1:1) and titrate the liberated hydrogen sulfide with the standard solution of potassium iodate, starch solution being used as an indicator.

Carry a blank through all steps of the process and deduct any sulfur that is found.

NOTE.—There is a question whether concentrated HCl or dilute HCl should be used. This method calls for concentrated HCl. See article by Pulsifer, "A Standard Apparatus for the Determination of Sulfur in Iron and Steel by the Evolution Method" in *Industrial and Engineering Chemistry*, p. 545, 1918.

21. *Calculation.*—If the potassium iodate solution has been adjusted to 0.0312 *N* and 5 g. of the alloy has been dissolved, then the percentage of sulfur is 0.01 times the number of milliliters of the iodate solution used.

OPTIONAL METHOD

22. For an optional method see the Determination of Sulfur by the Evolution-Titration Method (Routine) in the Standard Methods of Chemical Analysis of Plain Carbon Steel (A.S.T.M. Designation: A 33) of the American Society for Testing Materials.[1] This optional method may be used for Nickel-Chromium and for Nickel-Iron-Chromium Alloys with the following precautions:

1. Due to the length of time (30 minutes) required for solution of the alloy, closer observation is necessary than in the analysis of steel.

2. During the solution of the sample, care must be exercised in order that the absorbing solution is not drawn back into the flask.

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[1] 1933 Book of A.S.T.M. Standards, Part I, p. 326.

3. There is danger of contamination from rubber hose connections and rubber stoppers.

4. The use of a gas flame is a possible source of sulfur contamination and an electric heater is recommended.

Accuracy.—In the case of a sulfur content of 0.05 per cent, duplicate determinations should check within ±0.003 per cent sulfur.

DETERMINATION OF COPPER

A. Nickel-Copper Alloys Containing 10 to 90 per cent Copper

SOLUTIONS REQUIRED

23. The following reagents will be required:

Dilute Nitric Acid (1:3).—Slowly stir 50 ml. of HNO_3 (sp. gr. 1.42) into 150 ml. of distilled water.

Dilute Sulfuric Acid (1:1).—Slowly stir 10 ml. of concentrated H_2SO_4 (sp. gr. 1.84) into 10 ml. of water.

METHOD

24. Dissolve exactly 2.000 g. of the alloy in 25 ml. of the dilute HNO_3 (sp. gr. 1.135) and when solution is complete, boil to expel nitrous fumes and dilute with about 175 ml. of cold water. Add 5 ml. of the dilute sulfuric acid (1:1).

Determine the copper by electrolysis. Use a current of 0.5 ampere unless the solution is agitated, in which case a larger current up to 4 amperes may be used.

Accuracy.—Duplicate determinations should check within ±0.10 per cent of copper.

NOTE.—A little copper may be retained by the iron precipitate. The presence of molybdenum or silver will cause high results for copper.

B. Copper up to 5 per cent in Alloys of Chromium with Iron or Nickel or Both

SOLUTIONS REQUIRED

25. The following reagents will be required:

Ferric Sulfate.—Dissolve 0.8 g. of ferric sulfate ($Fe_2(SO_4)_3 \cdot 9\,H_2O$) in 100 ml. of distilled water.

Dilute Sulfuric Acid (1:4).—Slowly stir 50 ml. of H_2SO_4 (sp. gr. 1.84) into 200 ml. of distilled water.

Dilute Sulfuric Acid (1:1).—Slowly stir 100 ml. of H_2SO_4 (sp. gr. 1.84) into 100 ml. of distilled water.

Acidified Hydrogen Sulfide Water.—Mix 10 ml. of HCl (sp. gr. 1.19) and 1000 ml. of distilled water and saturate with H_2S.

Ammonium Hydroxide (sp. gr. 0.90).

METHOD

26. Dissolve exactly 5.000 g. of the alloy in a 400-ml. covered beaker in 100 ml. of HCl (sp. gr. 1.19) at about 65° C. When the reaction is complete, dilute to approximately 300 ml. with warm water. Introduce ammonium hydroxide (sp. gr. 0.90) until the solution is practically neutral and then add sufficient HCl (sp. gr. 1.19) to give an acidity of 3 ml. of HCl (sp. gr. 1.19) per 100 ml. of solution. Treat the solution with a brisk stream of hydrogen sulfide for at least 30 minutes.

Filter the precipitate of sulfide on a 9-cm. paper containing a small amount of paper pulp and wash thoroughly with the acidified hydrogen sulfide water. Discard the filtrate.

Return the paper and the precipitate to a 250-ml. covered beaker and treat with 3 ml. of H_2SO_4 (sp. gr. 1.84) and 25 ml. of HNO_3 (sp gr. 1.42) and evaporate slowly to fumes of sulfur trioxide. Add sufficient HNO_3 (sp. gr. 1.42) in small quantities to completely oxidize the filter paper and subsequently heat the solution until strong fumes of sulfur trioxide are evolved and all HNO_3 has been expelled.

Add 25 ml. of the ferric sulfate solution to the cooled sulfuric acid solution and add ammonium hydroxide (sp. gr. 0.90) in small excess. Heat the solution to boiling and after the precipitated ferric hydroxide has settled, filter on a 9-cm. paper and wash with hot water.

Dissolve the precipitate in a small amount of hot dilute H_2SO_4 (1:4) and wash the filter with water. Repeat the ammonia precipitation and the filtration and combine the filtrates. Acidify with an excess of 5 ml. of H_2SO_4 (1:1), add 1 ml. of HNO_3 (sp. gr. 1.42) and evaporate to approximately 100 ml.

Determine the percentage of copper by electrolysis, using a perforated platinum cathode and a spiral anode.

In case a trace of copper is to be determined, start with four 5-g. portions of sample and combine them after the hydrogen sulfide precipitates have been filtered.

Accuracy.—Duplicate determinations should check within ±0.02 per cent copper.

NOTE—A little copper may be retained by the iron precipitate. The presence of molybdenum or silver will cause high results for copper.

TENTATIVE SPECIFICATIONS
FOR
CONCRETE BUILDING BRICK[1]

A.S.T.M. Designation: C 55 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1924; REVISED, 1928, 1933.[2]

Scope

1. These specifications cover concrete building brick intended for use in brick masonry.

MANUFACTURE

Manufacture

2. Concrete building brick shall be manufactured from a mixture of portland cement and suitable aggregates, such as sand, gravel, crushed stone, bituminous or anthracite cinders, burned clay or shale, or blast-furnace slag.

PHYSICAL PROPERTIES AND TESTS

Physical Properties and Tests

3. (*a*) Concrete building brick shall be classified as Grades B and C on the basis of the following requirements. The classification of any lot of bricks shall be determined by the results of the tests for that requirement in which it is lowest, unless otherwise specified as provided in Section 8.

Classification	Compressive Strength (brick flatwise), lb. per sq. in., Mean Gross Area		Modulus of Rupture (brick flatwise), lb. per sq. in.	
	Mean of 5 Tests	Individual Minimum	Mean of 5 Tests	Individual Minimum
Grade B	2500 or over	2000	450 or over	300
Grade C	1250 to 2500	1000	300 to 450	200

NOTE.—The above classifications are based on strength and do not necessarily measure weathering resistance.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. J. W. Whittemore, Secretary of Committee C-3 on Brick, Virginia Polytechnic Inst., Blacksburg, Va.

[2] Latest revision accepted by Committee E-10 on Standards, March 8, 1933.

(*b*) The compressive strength and modulus of rupture tests shall be made in accordance with the Standard Methods of Testing Brick (Compression, Flexure, Absorption) (A.S.T.M. Designation: C 67) of the American Society for Testing Materials.[1]

Test Specimens

4. (*a*) For the purpose of tests, bricks representative of the commercial product shall be selected by a competent person appointed by the purchaser, the place or places of selection to be designated when the purchase order is placed. The manufacturer or seller shall furnish specimens for tests without charge. All bricks shall be carefully examined and their condition noted before testing. For the purpose of tests, not less than ten bricks shall be required for each investigation. In general, two samples of ten bricks each shall be tested for every 100,000 bricks contained in the lot under consideration; but where the total quantity exceeds 500,000 bricks, one sample of ten bricks from each 100,000 bricks shall be tested. Additional representative samples may be taken at any time or place at the discretion of the purchaser.

(*b*) Concrete building brick when tested shall be at least 28 days old, unless otherwise mutually agreed upon between the manufacturer and the purchaser. Representative samples from brick delivered on the job may be tested at any time by the purchaser.

Size

SIZE

5. Concrete building brick shall be $2\frac{1}{4}$ by $3\frac{3}{4}$ by 8 in. with a permissible variation of $\pm\frac{1}{16}$ in. in depth, $\pm\frac{1}{8}$ in. in width and $\pm\frac{1}{4}$ in. in length.

WORKMANSHIP AND FINISH

Workmanship and Finish

6. When any particular surface appearance or uniformity is desired, it shall be mutually agreed upon between the manufacturer and the purchaser.

VISUAL INSPECTION AND REJECTION

Inspection and Rejection

7. Brick shall pass a visual inspection for freedom from cracks and irregularity. Cracked or misshaped brick shall be rejected.

Acceptance

8. At the option of the purchaser, acceptance may be based on the visual inspection requirements specified in Section 7 and on the results of one of the strength tests (compression or flexure) specified in Section 3.

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[1] 1933 Book of A.S.T.M. Standards, Part II, p. 128.

TENTATIVE SPECIFICATIONS
FOR
STRUCTURAL CLAY FLOOR TILE[1]

A.S.T.M. Designation: C 57 – 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1933.

Scope

1. These specifications apply to structural clay floor tile made from surface clay, shale, fire clay or admixtures thereof.

CLASSIFICATION

Classification

2. (*a*) According to the results of physical tests, tile to be used in flat or segmental arches or used to resist stresses in combination tile and concrete ribbed slab construction, shall be classified as 5–16 and 16–25 on the basis of the following strength and absorption requirements:[2]

Class	Absorption, per cent			Compressive Strength Based on Net Area,[a] lb. per sq. in.			
	Average of 5 Tests	Individual Maximum	Individual Minimum	End-Construction Tile		Side-Construction Tile	
				Average of 5 Tests	Individual Minimum	Average of 5 Tests	Individual Minimum
5-16...........	5 to 16	19	4	3200 or more	2250	1600 or more	1100
16-25...........	25 or less	28	4	2000 or more	1400	1200 or more	850

[a] Net area of a unit shall be taken as the area of solid material in shells and webs actually carrying stresses in a direction parallel to direction of loading.

(*b*) Where end-construction tile are used on the side they shall conform to the requirements of that construction, and *vice versa.*

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. F. E. Emery, Secretary of Committee C-10 on Hollow Masonry Building Units, Structural Clay Tile Assn., 8 West 40th St., New York City.

These specifications are in effect a tentative revision of, and will supersede when adopted as standard, the present specification requirements in Sections 1 to 10, inclusive, of the Standard Specifications and Tests for Structural Clay Floor Tile (C 57 – 31), see 1933 Book of A.S.T.M. Standards, Part II, p. 132.

[2] As different types of clay are used in the manufacture of tile, color is not a reliable indication of classification.

WEIGHTS

Weights

3. (*a*) Flat and segmental arch tile shall conform to the following requirements as to minimum number of cells in arch thickness and average dry weights per square foot of tile:

FLAT ARCH TILE

DEPTH OF ARCH, IN.	MINIMUM NUMBER OF CELLS IN ARCH THICKNESS	AVERAGE DRY WEIGHT, LB. PER SQ. FT OF TILE
6	1	26
7	1	30
8	2	32
9	2	33
10	2	35
11	2	38
12	2	40
13	2	43
14	3	46
15	3	47
16	3	52

SEGMENTAL ARCH TILE

DEPTH OF ARCH, IN.	MINIMUM NUMBER OF CELLS IN ARCH THICKNESS	AVERAGE DRY WEIGHT, LB. PER SQ. FT OF TILE
6	2	30
8	2	36

(*b*) A tolerance of 5 per cent under and 12.5 per cent over will be allowed on the average dry weights specified in Paragraph (*a*).

(*c*) Tile designed to resist stresses in combination tile and concrete ribbed slab construction shall conform to the following requirements as to minimum number of cells in thickness and average dry weights per square foot of tile:

THICKNESS OF UNITS, IN.	MINIMUM NUMBER CELLS IN THICKNESS OF TILE	AVERAGE DRY WEIGHTS, LB. PER SQ. FT. OF TILE
3	1	15
4	1	16
5	1	19
5	2	23
6	1	22
6	2	25
7	1	24
7	2	27
8	1	27
8	2	29
9	2	31
9	3	36
10	2	33
10	3	38
12	2	40
12	3	45

(*d*) A tolerance of ± 10 per cent will be allowed on the average weights per square foot specified in Paragraph (*c*).

(*e*) Structural clay floor tile units may be made any size consistent with economic considerations of manufacturing and practicable engineering standards of design.

DIMENSIONS AND PERMISSIBLE VARIATIONS

Dimensions

4. No dimension shall vary more than ± 3 per cent from the standard dimensions for any form of tile.

WORKMANSHIP AND FINISH

Workmanship

5. All tile shall be well burned, reasonably free from laminations and from such cracks, blisters, surface roughness and other defects as would interfere with the proper setting of the tile or impair the strength or permanence of the construction.

Scoring

6. The exterior surface of all tile intended for plaster shall be scratched or scored. When scored, each groove shall be not less than $\frac{1}{8}$ in. nor more than $\frac{3}{16}$ in. in depth, nor more than 1 in. in width. The area covered by the grooves shall not exceed 50 per cent of the area of the scored faces.

MARKING

Marking

7. All tile shall bear the initials, name or trademark of the manufacturer. These marks shall be indented on the exterior of the tile and shall be plainly legible.

INSPECTION AND REJECTION

Inspection

8. Proper facilities shall be provided the purchaser for sampling and inspection either at the factory or at the site of the work, as may be specified. At least 10 days from the time of sampling shall be allowed for the completion of the test. The inspection shall be based on the requirements specified in Sections 2 to 7, inclusive. All tests shall be made in accordance with the methods specified in Section 11.

Rejection

9. (*a*) Individual tile shall be rejected for failure to meet the weight, size, or workmanship and finish requirements. In case of failure to meet the absorption and strength requirements for the class

specified, the manufacturer may sort the shipment and new samples shall be selected by the purchaser from the retained lot and tested at the expense of the manufacturer. In case the second set of samples fails to meet the test requirements the entire lot shall be rejected.

Acceptance

(*b*) By agreement, acceptance may be based on dry weight of the units, percentage of absorption, and the workmanship and finish.

Expense of Tests

10. Except as specified in Section 9 and unless otherwise agreed, the expense of inspection and testing shall be borne by the purchaser.

Methods of Testing

11. Tile shall be sampled and tested in accordance with Sections 11 to 28 of the Standard Specifications and Tests for Structural Clay Floor Tile (A.S.T.M. Designation: C 57–31) of the American Society for Testing Materials.[1]

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[1] 1933 Book of A.S.T.M. Standards, Part II, p. 132.

TENTATIVE SPECIFICATIONS
FOR
STRUCTURAL CLAY NON-LOAD-BEARING TILE[1]

A.S.T.M. Designation: C 56 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1933.

Scope

1. These specifications apply to structural clay partition, fireproofing and furring tile made from surface clay, shale, fire clay or admixtures thereof.

CLASSIFICATION

Classification

2. According to results of physical tests, tile shall be classified as 5–16 and 16–25 on the basis of the following absorption requirements:[2]

	Absorption, per cent		
Class	Average of Five Tests	Individual Maximum	Individual Minimum
5–16	5 to 16	19	4
16–25	16 to 25	28	4

WEIGHTS

Weights

3. Partition and split-furring tile shall conform to the following requirements as to minimum number of cells and dry weights per square foot of tile:

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. F. E. Emery, Secretary of Committee C-10 on Hollow Masonry Building Units, Structural Clay Tile Assn., 8 West 40th St., New York City.

These specifications are in effect a tentative revision of, and will supersede when adopted as standard, the present specification requirements in Sections 1 to 10, inclusive, of the Standard Specifications and Tests for Structural Clay Fireproofing, Partition and Furring Tile (C 56 - 31), see 1933 Book of A.S.T.M. Standards, Part II, p. 137.

[2] As different types of clay are used in the manufacture of tile, color is not a reliable indication of classification.

PARTITION TILE

DIMENSIONS, IN.	MINIMUM NUMBER CELLS IN UNIT	MINIMUM NUMBER CELLS IN WALL THICKNESS	MINIMUM AVERAGE WEIGHT, LB. PER SQ. FT. OF TILE	MAXIMUM AVERAGE WEIGHT, LB. PER SQ. FT. OF TILE	INDIVIDUAL MINIMUM WEIGHT, LB. PER SQ. FT. OF TILE
2 by 12 by 12	3	1	14	16	13
3 by 12 by 12	3	1	15	17	14
4 by 12 by 12	3	1	16	18	15
6 by 12 by 12	3	1	22	25	21
6 by 12 by 12	4	2	25	28	24
8 by 12 by 12	4	2	30	34	28
10 by 12 by 12	4	2	35	40	33
12 by 12 by 12	4	2	40	45	38
SPLIT FURRING TILE					
1½ by 12 by 12	3	..	7½	8½	7
2 by 12 by 12	3	..	8	9	7½

DIMENSIONS AND PERMISSIBLE VARIATIONS

Dimensions

4. No dimension shall vary more than ± 3 per cent from the specified dimensions for any form of tile.

WORKMANSHIP AND FINISH

Workmanship

5. All tile shall be well burned, reasonably free from laminations and from such cracks, blisters, surface roughness and other defects as would evidently interfere with the proper setting of the tile or impair the permanence of the construction.

Scoring

6. The exterior surface of all tile intended for plaster or stucco shall be scratched or scored. When scored, each groove shall be not less than $\frac{1}{8}$ in. nor more than $\frac{3}{16}$ in. in depth, nor more than 1 in. in width. The area covered by the grooves shall not exceed 50 per cent of the area of the scored faces.

MARKING

Marking

7. All tile shall bear the initials, name or trademark of the manufacturer. These marks shall be indented on the exterior of the tile and shall be plainly legible.

INSPECTION AND REJECTION

Inspection

8. Proper facilities shall be provided the purchaser for sampling and inspection either at the factory or at the site of the work, as may

be specified in the contract. At least 10 days from the time of sampling shall be allowed for the completion of the test. The inspection shall be based on the requirements specified in Sections 2 to 7, inclusive. All tests shall be made in accordance with the methods specified in Section 11.

Rejection

9. (*a*) Individual tile shall be rejected for failure to meet the weight, size, or workmanship and finish requirements. In case of failure to meet the absorption requirements for the class specified, the manufacturer may sort the shipment and new samples shall be selected by the purchaser from the retained lot and tested at the expense of the manufacturer. In case the second set of samples fails to meet the test requirements, the entire lot shall be rejected.

Acceptance

(*b*) By agreement, acceptance may be based on dry weight of the units, percentage of absorption, and the workmanship and finish.

Expense of Tests

10. Except as specified in Section 9, and unless otherwise agreed, the expense of inspection and testing shall be borne by the purchaser.

Methods of Testing

11. Tile shall be sampled and tested in accordance with Sections 11 to 22 of the Standard Specifications and Tests for Structural Clay Fireproofing, Partition and Furring Tile (A.S.T.M. Designation: C 56 – 31) of the American Society for Testing Materials.[1]

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[1] 1933 Book of A.S.T.M. Standards, Part II, p. 137.

TENTATIVE SPECIFICATIONS
FOR
STRUCTURAL CLAY LOAD-BEARING WALL TILE[1]

A.S.T.M. Designation: C 34 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1933.

Scope

1. These specifications apply to structural clay load-bearing wall tile made from surface clay, shale, fire clay or admixtures thereof.

CLASSIFICATION

Classification

2. (*a*) According to results of physical tests, tile shall be classified as 5–16 and 16–25 on the basis of the following strength and absorption requirements:[2]

Class	Absorption, per cent			Compressive Strength Based on Gross Area,[a] lb. per sq. in.			
	Average of 5 Tests	Individual Maximum	Individual Minimum	End-Construction Tile		Side-Construction Tile	
				Average of 5 Tests	Individual Minimum	Average of 5 Tests	Individual Minimum
5-16	5 to 16	19	4	1400 or more	1000	700 or more	500
16-25	25 or less	28	4	1000 or more	700	500 or more	350

[a] Gross area of a unit shall be the total area of a section including cells perpendicular to the direction of loading. Re-entrant spaces are included in the gross area, unless these spaces are to be occupied in masonry by portions of adjacent units.

(*b*) Where end-construction tile are used on the side they shall conform to the requirements of that construction, and *vice versa*.

(*c*) All tile shall be so designed that substantially the same masonry strength will be developed in all wall thicknesses for which they are to be used.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. F. E. Emery, Secretary of Committee C-10 on Hollow Masonry Building Units, Structural Clay Tile Assn., 8 West 40th St., New York City.

These specifications are in effect a tentative revision of, and will supersede when adopted as standard, the present specification requirements in Sections 1 to 11, inclusive, of the Standard Specifications and Tests for Structural Clay Load-Bearing Wall Tile (C 34 - 31), see 1933 Book of A.S.T.M. Standards, Part II, p. 141.

[2] As different types of clay are used in the manufacture of tile, color is not a reliable indication of classification.

(*d*) Bonding tile shall be so designed as to provide recesses for header brick courses when laid up in brick-faced walls.

WEIGHTS AND NUMBER OF CELLS[a] IN WALL THICKNESS

Weights and Number of Cells

3. (*a*) Load-bearing tile shall conform to the following requirements as to minimum number of cells[a] in wall thickness and dry weights per square foot of tile:

NOMINAL HORIZONTAL THICKNESS OF TILE AS LAID IN WALL, IN.	MINIMUM NUMBER OF CELLS IN WALL THICKNESS	MINIMUM AVERAGE WEIGHT, LB. PER SQ. FT. OF TILE	MAXIMUM AVERAGE WEIGHT, LB. PER SQ. FT. OF TILE	INDIVIDUAL MINIMUM WEIGHT, LB. PER SQ. FT. OF TILE
4	1	20	23	19
6	2	30	35	28
8	2	36	41	34
10	2	42	48	40
12	3	52	60	49

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[a] Hollow spaces enclosed within the perimeter of the exterior shells and having a minimum dimension of not less than ½ in. and a cross-sectional area of not less than 1 sq. in.

(*b*) The weight of bonding tile, including complementary shapes, shall be governed by the requirements specified in Paragraph (*a*) and shall be calculated from the average weight of the one or more units required between header brick courses. In calculating area of tile, the greatest vertical face dimension shall be used.

(*c*) In double-shell tile the two voids between exterior and interior shells on either side of the tile shall be considered as one cell in thickness of wall when their combined width is not less than ½ in., provided the short webs between the inner and outer shells are not greater in number or thickness than the long transverse webs holding the inner shells.

(*d*) Re-entrant spaces not less than 1 in. in depth and not less than 1 sq. in. in area, which form cells when the units are laid up in the wall, shall be considered as cells in wall thickness, but not in the units.

DIMENSIONS AND PERMISSIBLE VARIATIONS

Dimensions

4. (*a*) The thickness of bonding and other types of tile manufactured for use in combination with brick or other materials may vary from the nominal thicknesses specified in Section 3, as required by construction requirements, but no dimensions shall vary more than ± 3 per cent from the purchasers' or manufacturers' specified dimensions.

(*b*) The average over-all thickness of the shells measured between the inner and extreme outer surfaces of end-construction load-bearing tile shall be at least $\frac{3}{4}$ in., except in double-shell tile the combined average over-all thickness of the inner and outer shell shall be not less than $\frac{3}{4}$ in. The minimum thickness of the webs shall be not less than $\frac{1}{2}$ in.

(*c*) The width of cells in side-construction tile, measured in the direction of wall thickness, shall not exceed five times the average over-all thickness of either the upper or lower bearing shells.

WEATHERING RESISTANCE

Weathering Resistance

5. All tile which will be subjected to weathering conditions or intended to be stuccoed shall be able to withstand 100 alternate freezings and thawings. Tile classed as 5–16 by these specifications may be considered as meeting the weathering requirements, provided they are burned to a normal maturity for the given clay. Tile classed as 16–25 shall be accepted as meeting the weathering requirements only on the basis of freezing-and-thawing tests.

WORKMANSHIP AND FINISH

Workmanship

6. All tile shall be well burned, reasonably free from laminations and from such cracks, blisters, surface roughness, and other defects as would interfere with the proper setting of the tile or impair the strength or permanence of the construction.

Scoring

7. The exterior surface of all tile intended for plaster or stucco shall be scratched or scored. When scored, each groove shall be not less than $\frac{1}{8}$ in. nor more than $\frac{1}{4}$ in. in depth, nor more than 1 in. in width. The area covered by the grooves shall not exceed 50 per cent of the area of the scored faces.

MARKING

Marking

8. All load-bearing tile shall bear the word "Load-Bearing" or "L-B," and name, initials or trademark of the manufacturer. These marks shall be indented on the exterior of the tile and shall be plainly legible.

INSPECTION AND REJECTION

Inspection

9. Proper facilities shall be provided the purchaser for sampling and inspection either at the factory or at the site of the work, as may

be specified. At least 10 days from the time of sampling shall be allowed for the completion of the test. The inspection shall be based on the requirements specified in Sections 2 to 8, inclusive. All tests shall be made in accordance with the methods specified in Section 12.

Rejection

10. Individual tile shall be rejected for failure to meet the weight, number of cells, specified size, or workmanship and finish requirements. In case of failure to meet the absorption and strength requirements for the class specified, the manufacturer may sort the shipment and new samples shall be selected by the purchaser from the retained lot and tested at the expense of the manufacturer. In case the second set of samples fails to meet the test requirements the entire lot shall be rejected.

Expense of Tests

11. Except as specified in Section 10 and unless otherwise agreed, the expense of inspection and testing shall be borne by the purchaser.

Methods of Testing

12. Tile shall be sampled and tested in accordance with Sections 12 to 34 of the Standard Specifications and Tests for Structural Clay Load-Bearing Wall Tile (A.S.T.M. Designation: C 34 – 31) of the American Society for Testing Materials.[1]

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[1] 1933 Book of A.S.T.M. Standards, Part II, p. 141.

TENTATIVE SPECIFICATIONS AND TESTS FOR LOAD-BEARING CONCRETE MASONRY UNITS[1]

A.S.T.M. Designation: C 90 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931; REVISED, 1933.[2]

SPECIFICATIONS

Scope.

1. These specifications apply to strength, absorption and general requirements of hollow load-bearing concrete masonry wall units made from portland cement and suitable aggregates such as sand, gravel, crushed stone, bituminous or anthracite cinders, burned clay or shale, and blast-furnace slag.[3]

COMPRESSIVE STRENGTH

Compressive Strength.

2. The average compressive strength of five units at the time of delivery to the site shall be not less than the following:

MINIMUM FACE SHELL THICKNESS, IN.	COMPRESSIVE STRENGTH BASED ON GROSS AREA, LB. PER SQ. IN. MEAN OF FIVE TESTS	INDIVIDUAL MINIMUM
$1\frac{1}{4}$ or over	700	600
Under $1\frac{1}{4}$ and over $\frac{3}{4}$	1000	800

ABSORPTION

Absorption.

3. (*a*) Concrete masonry units which will be exposed to the weather or soil in the finished work (without brick, stucco or other suitable protective covering approved by the purchaser) shall not absorb more than 15 lb. of water per cubic foot of concrete actually contained.

(*b*) Units which will be suitably protected from the weather or soil in the finished work need not conform to the absorption requirement specified in Paragraph (*a*).

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. F. E. Emery, Secretary of Committee C-10 on Hollow Masonry Building Units, Structural Clay Tile Assn., 8 West 40th St., New York City.

[2] Revision accepted by Committee E-10 on Standards, August 16, 1933.

[3] When fire tests are required they shall be conducted in accordance with the Standard Specifications for Fire Tests of Building Construction and Materials (A.S.T.M. Designation: C 19), see 1933 Book of A.S.T.M. Standards, Part II, p. 254.

DIMENSIONS AND PERMISSIBLE VARIATIONS

Dimensions.

4. No dimension shall vary more than 3 per cent over or under the specified dimension for any form or size of unit.

WORKMANSHIP AND FINISH

Workmanship and Finish.

5. (*a*) All units shall be sound and free from cracks or other defects as would interfere with the proper placing of the unit or impair the strength or permanence of the construction.

(*b*) Units which are intended to serve as a base for plaster or stucco shall have a sufficiently rough surface to give good bond.

MARKING

Marking.

6. All units shall bear a distinctive mark of the manufacturer or shall otherwise be readily identified as to origin.

INSPECTION AND REJECTION

Inspection.

7. Proper facilities shall be provided the purchaser for sampling and inspection either at the factory or at the site of the work, as may be specified in the contract. The inspection shall be based on the requirements specified above. At least ten days from the time of sampling shall be allowed for the completion of tests. All tests shall be made in accordance with the methods specified in Sections 10 to 25.

Rejection.

8. Individual units shall be rejected for failure to meet size or workmanship and finish requirements. In case of failure to meet the strength and/or absorption requirements, the manufacturer may sort the shipment and new samples shall be selected by the purchaser from the retained lot and tested at the expense of the manufacturer. In case the second set of samples fails to meet the test requirements the entire set shall be rejected.

Expense of Tests.

9. Except as specified in Section 8 and unless otherwise agreed, the expense of inspection and testing shall be borne by the purchaser.

METHODS OF TESTING

SAMPLING

Selection of Samples for Test.

10. Samples of units for testing shall be selected and tested by the purchaser or by a competent representative authorized by him to do this work. In all cases the samples shall be representative of the whole lot of units from which they are selected. Full-size units shall be taken in all cases.

Number of Samples.

11. For the strength and absorption determinations, ten individual units shall be selected from each lot of 10,000 units or fraction

thereof; 20 individual units from each lot of more than 10,000 and less than 100,000 units. For lots of more than 100,000 units ten individual units shall be selected from each 50,000 units contained in the lot. Where the absorption determination is not required the number of units taken may be reduced by half.

Time and Place of Selecting Samples. 12. Samples for the strength and absorption tests shall be selected at the factory or at the site of the work, as specified.

Marking Samples. 13. All units selected for purpose of tests shall be plainly and permanently marked for reference by the testing operator.

COMPRESSIVE STRENGTH TESTS

Samples. 14. Five full-size units shall be used. The units shall be in an air-dry condition equivalent to that obtained by a period of seven days' protection from the weather at room temperature at from 60 to 80° F.

Speed of Testing Machine. 15. The speed of the moving head of the testing machine shall be not more than 0.05 in. per minute.

Bearing Block. 16. A spherical bearing block of proper design shall be placed on top of the test specimen. When the bearing area of the spherical bearing block is not sufficient to cover the area of the specimen, metal plates of sufficient thickness to prevent appreciable bending shall be placed between the spherical bearing block and the specimen.

Capping. 17. (*a*) Bearing surfaces of the test specimens and portions adjoining them which are liable to absorb water from the plastic capping shall be coated with shellac and allowed to dry.

(*b*) A quantity of plastic mortar made of a mixture of one part (by volume) of portland cement and one part of unretarded gypsum (plaster of Paris) mixed with sufficient water to spread evenly shall be placed on a plain surface which has been coated with oil. The surface to be capped shall be placed on this mortar, and while holding the specimen so that its axis is at right angles to the capping surface it shall be given a single firm pressure.

(*c*) The average thickness of the cap after the extruded plaster has been removed and the edges trued shall be not more than $\frac{1}{8}$ in. Patching of caps after setting shall not be permitted. Imperfect caps shall be removed and replaced with new ones.

Time of Testing. (*d*) The cap shall age at least six hours before the unit is tested.

(*e*) When the specimens are made with irregular bearing surfaces, a 1:2 portland-cement mortar may be used to provide plane surfaces prior to capping.

18. All units shall be tested in a position such that the load is applied in the same direction as in service. **Position of Unit.**

19. The compressive strength of a unit shall be the maximum load applied divided by the gross cross-sectional area in square inches. **Calculation.**

ABSORPTION TESTS

20. The samples shall consist of five whole units or pieces from each one of five units. If pieces are used they shall weigh not less than one-third the weight of the whole unit from which they were taken and in no case less than 5 lb. The samples shall have had any loose particles removed and any rough or jagged edges ground smooth. **Selection of Test Samples.**

21. Each piece shall be marked so that it may be identified at any time with the unit from which it was taken. Markings which do not cover more than 5 per cent of the total superficial area of the piece shall be used. **Marking Test Samples.**

22. Preparatory to the absorption tests, all samples shall be dried in a drier or oven at a temperature between 100 and 115° C. (212 and 239° F.) and weighed at 24-hour intervals until the loss in weight does not exceed 1 per cent of the last previous weight. **Drying Test Samples.**

23. The balance used shall be accurate to within 0.5 per cent of the weight of the smallest unit or piece tested. **Accuracy of Weighings.**

24. The dry weight of the samples shall be obtained after which they shall be immersed completely in water at room temperature at from 15.6 to 26.7° C. (60 to 80° F.) for 24 hours. The samples shall then be weighed while suspended with a metal wire and completely submerged in water. They shall be removed from the water and allowed to drain for 60 seconds by placing on $\frac{3}{8}$-in. or coarser wire mesh, visible surface water being removed with a damp cloth, and immediately weighed. **Saturation of Samples.**

25. The absorption in pounds per cubic foot is equal to 62.4 times the difference between the wet and dry weights divided by the difference between the wet and suspended immersion weights, as follows: **Calculations.**

$$\text{Absorption, lb. per cu ft.} = \frac{(\text{Wet Weight} - \text{Dry Weight}) \times 62.4}{\text{Wet Weight} - \text{Suspended Immersion Weight}}$$

TENTATIVE DEFINITIONS

OF

TERMS RELATING TO STRUCTURAL CLAY TILE[1]

A.S.T.M. Designation: C 43 – 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1933.

TILE

Structural Clay Tile.—Hollow burned-clay masonry building units with parallel cells.

NOTE.—The term "tile" is understood, within the meaning of these definitions, to mean "structural clay tile." The term "terra cotta," which is applied to ornamental building units of burned clay, should not be used to designate structural clay tile.

Load-Bearing Tile.—Tile for use as load-bearing structural units in masonry walls.

Fireproofing Tile.—Tile for use as a protection for structural members against fire.

Partition Tile.—Tile for use in building interior partitions, subdividing areas into rooms, or similar construction, and carrying no superimposed loads.

Furring Tile.—Tile for lining the inside of walls and carrying no superimposed loads.

Foundation Tile.—Tile for use as load-bearing structural units in foundation walls.

Floor Tile.—Tile for use as structural units in floor and roof construction.

Bonding Tile.—Tile designed to provide recesses for header brick in brick-faced walls.

Book Tile.—Tile with tongue and groove edges resembling a book in shape.

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[1] Criticisms of these Tentative Definitions are solicited and should be directed to Mr. F. E. Emery, Secretary of Committee C-10 on Hollow Masonry Building Units, Structural Clay Tile Assn., 8 West 40th St., New York City.

These definitions are in effect a tentative revision of the present Standard Definitions of Terms Relating to Structural Clay Tile (A.S.T.M. Designation: C 43 – 31), which standard definitions they are intended to eventually supersede, see 1933 Book of A.S.T.M. Standards, Part II, p. 147.

GENERAL TERMS

Side-Construction Tile.—Tile designed to receive its principal stress at right angles to the axes of the cells.

End-Construction Tile.—Tile designed to receive its principal stress parallel to the axes of the cells.

Salt-Glazed Tile.—Tile with vitreous glaze on its surface produced by burning salt in the kiln at the temperature used in finishing the burning.

Porous Structural Clay Tile.—Tile in which the natural porosity of the clay has been increased by the admixture of other ingredients.

RAW MATERIALS

Shale.—A thinly stratified, consolidated, sedimentary clay[1] with well-marked cleavage parallel to the bedding.

Fire Clay.—A sedimentary clay[1] of low flux content.

NOTE.—It is usually associated with coal measures.

Surface Clay.—An unconsolidated, unstratified clay,[1] occurring on the surface.

DESIGNATION OF DIMENSIONS

Length.—That dimension measured between the cut ends.

Thickness.—That dimension designed to lie at right angles to the face of the wall, floor, or other member in which it is used.

Width.—That dimension measured at right angles to the direction of its thickness and length.

NOTE 1.—In practice, the first dimension given represents thickness; the second, width; the third, length.

NOTE 2.—Gross area is taken as total area enclosed by the outside dimensions of the unit in a direction perpendicular to that in which load is carried.

NOTE 3.—Net area shall be taken as the area of solid material in shells and webs actually carrying stresses through the units in a direction parallel to the direction of loading.

PARTS, OPENINGS AND SURFACE FEATURES

Shell.—The outer walls.

Webs.—The partitions dividing it into cells.

Cells.—Hollow spaces enclosed within the perimeter of the exterior shells and having a minimum dimension of not less than ½ in. and a cross-sectional area of not less than 1 sq. in.

Scoring.—The grooves formed in the exterior faces of the shells to increase the bond of mortar, plaster, or stucco.

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[1] The definitions for the terms "shale," "fire clay" and "surface clay" are based upon the following definition of the term "clay":

Clay.—An earthy or stony mineral aggregate consisting essentially of hydrous silicates of alumina, plastic when sufficiently pulverized and wetted, rigid when dry, and vitreous when fired to a sufficiently high temperature.

TENTATIVE METHODS OF TESTING HIGH-TEMPERATURE HEAT INSULATION[1]

(COMPRESSION, FLEXURE, SHRINKAGE)

A.S.T.M. Designation: C 93 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1933.

Scope

1. These methods cover the following tests for high-temperature insulation:

Compression test;
Flexure or cross-bending test; and
Shrinkage test.

COMPRESSION TEST

Apparatus

2. Any form of standard testing machine may be used for the compression test together with a spherical bearing block large enough entirely to cover the specimen.

Test Specimen

3. The test specimen shall consist of a half-brick, measuring approximately 4½ by 4½ by 2½ in.

NOTE.—This permits the use of a suitable half-brick from the flexure test.

Condition of Test Specimen

4. The surfaces of the material to be tested shall be true planes and parallel.

Number of Tests

5. Compression tests shall be made on at least ten half-brick test specimens from different bricks.

Procedure

6. (*a*) The half-brick test specimen shall be tested, placed flat.

(*b*) The bearing block shall be used on top of the test specimen in vertical testing machines. The center of the sphere of the bearing block shall be used in contact with the top bearing surface of the specimen, and in the vertical axis of the specimen. (See Fig. 1.) The spherical bearing block shall be kept thoroughly lubricated to insure accurate adjustment, which should be made by hand under a small initial load.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. C. E. Bales, Secretary of Committee C-8 on Refractories, Ironton Fire Brick Co., Ironton, Ohio.

(*c*) The speed of the moving head of the testing machine, during the application of the load, shall not be more than 0.05 in. per minute.

(*d*) During the test the beam of the testing machine shall be kept constantly in a floating position.

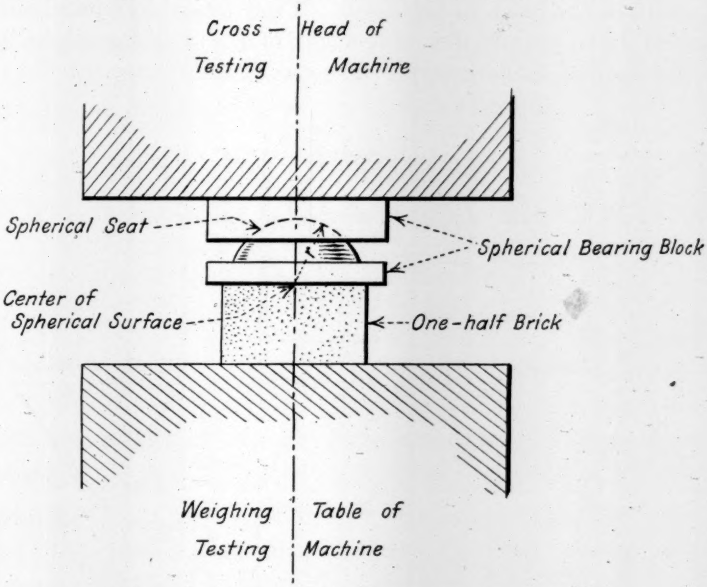

FIG. 1.—Spherical Bearing Block for Compression Test.

(*e*) The test specimen shall be compressed to a deformation of 5 per cent of the original thickness, unless definite failure shall have previously occurred. The load value reported shall be the maximum obtained.

Compressive Strength

7. The compressive strength in pounds per square inch shall be reported as the total maximum load, W, in pounds, indicated by the testing machine, divided by the average of the gross areas of the top and bottom of the specimen, A, in square inches, of the section of the specimen perpendicular to the line of application of the load.

The compressive strength in pounds per square inch shall be calculated from the formula:

$$\text{Compressive strength} = \frac{W}{A}$$

FLEXURE TEST

Apparatus

8. (*a*) Any form of standard testing machine with knife edges as described in Paragraph (*b*) may be used for the flexure test.

NOTE.—Portable apparatus properly calibrated may be used.

(*b*) Knife edges shall be straight and have full contact with the specimen or bearing plate and they shall have a length at least equal to the width of the brick to be tested. Their bases shall be so curved or rounded as to permit free movement of the working edges, both longitudinally and transversely. The use of knife edges of the type shown in Fig. 2 is recommended, although other types may be used which will provide free movement and at the same time insure full and even bearing at all times during the test.

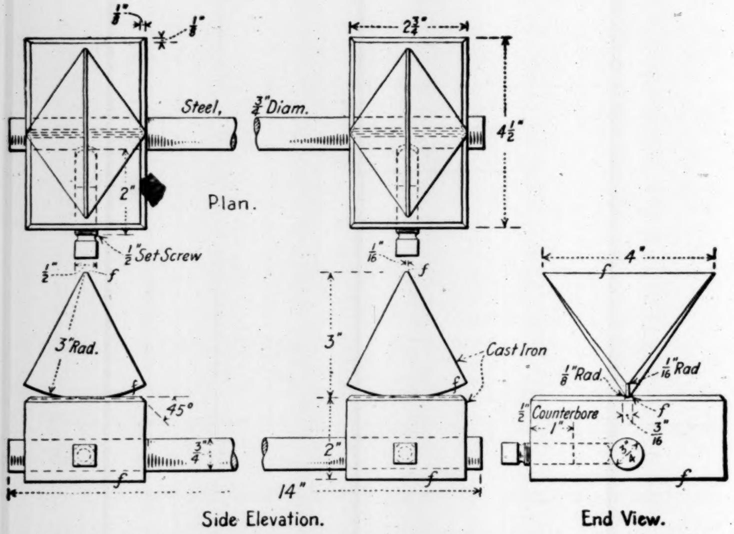
1/8"
1/8"
Steel,
3/4" Diam.
2 3/4"
4 1/2"
2"
Plan.
1/2" Set Screw
1/2"
f
1/16"
f
4"
f
3" Rad.
3"
Cast Iron
1/8" Rad.
1/16" Rad
45°
1/2" Counterbore
1"
f
3/16"
3/4"
2"
14"
f
f
f
Side Elevation.
End View.

FIG. 2.—Knife-Edge Bearing Device.

Test Specimen

9. The test specimen shall preferably be 9 by 4½ by 2½ in. If a specimen having dimensions other than these are used, they shall be reported.

Number of Tests

10. Flexure tests shall be made on at least ten test specimens.

Procedure

11. (*a*) A test specimen shall be placed flat-wise on the knife edges with a span of 7 in. and the load applied at mid-span.

(*b*) A steel bearing piece $\frac{1}{4}$ in. in thickness, $1\frac{1}{2}$ in. in width and of a length equal to the full width of the specimen shall be placed between the upper knife edge and the specimen.

(*c*) The speed of the moving head of the testing machine, during the application of the load, shall not be more than 0.05 in. per minute.

Modulus of Rupture

12. The modulus of rupture, R, in pounds per square inch shall be reported as calculated from the following formula:

$$R = \frac{3\,Wl}{2\,bd^2}$$

where W = the total load in pounds at which the brick failed;
l = the distance between the supports in inches;
b = the width of the brick in inches; and
d = the depth of the brick in inches.

SHRINKAGE TEST

Scope

13. The object of this test is to determine the permanent heat shrinkage of the specimen when subjected to a definite temperature.

Test Furnace

14. The test furnace may be any suitable furnace in which uniform temperatures can be obtained.

15. The test specimen shall preferably be 9 by $4\frac{1}{2}$ by $2\frac{1}{2}$ in.

Procedure

16. (*a*) The test specimen shall be measured along the three major axes through the center of the specimen. The measurements shall be made to the nearest 0.01 in.

(*b*) The test specimen shall be placed in the furnace on the 9 by $4\frac{1}{2}$ in. surface. The specimen shall be protected from direct flame or localized heating from direct contact with furnace parts.

(*c*) The maximum temperature to be used shall depend upon the material. This maximum temperature shall be obtained in not less than three hours. The maximum temperature shall be maintained for a period of five hours. The specimen shall be left in the furnace until the furnace temperature has fallen to at least 500 F. (260 C.).

Volume Shrinkage

17. The volume shrinkage shall be calculated from the measurements along the three major axes through the center of the specimen, in accordance with the following formula:

$$\text{Volume shrinkage, per cent} = \frac{V_o - V_f}{V_o} \times 100$$

where V_o = the original volume; and
V_f = the final volume.

Linear Shrinkage

18. The linear shrinkage shall be calculated from the volume shrinkage by the following formula:

$$L = 100\left[1 - \sqrt[3]{1 - \frac{V}{100}}\right]$$

TENTATIVE METHOD OF CONTROL TEST

FOR

RESISTANCE OF FIRE-CLAY BRICK TO THERMAL SPALLING ACTION[1]

A.S.T.M. Designation: C 38 – 33 T

This is a Tentative Standard, published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1921; REVISED, 1926, 1927, 1931, 1933.

Object. 1. This method of control test is intended for determining the comparative resistance of high-duty fire-clay brick to spalling action by subjecting them to repeated rapid temperature changes. It is not to be used as a suitability test, as experience has shown that results obtained in this control test are not comparable with results obtained in service on the same brand of brick. This test is of value, however, as a control test in maintaining the uniformity of fire-clay brick in so far as thermal spalling is concerned.

Preparation of Samples. 2. (*a*) The sample shall consist of at least five standard 9-in. brick or of five shapes, which may be cut to standard size with a grinding wheel.

(*b*) Test specimens of shapes such as boiler arch brick shall be cut to the standard 9-in. size. For this purpose a "cut-off" wheel is recommended.

Procedure. 3. (*a*) The specimens shall be weighed and placed in a door of a furnace operated at 1350° C. (2462° F.), care being taken to prevent the direct heating of more than the $2\frac{1}{2}$ by $4\frac{1}{2}$-in. end. After one hour the specimen shall be withdrawn from the furnace and stood on end in a tank (Fig. 1) of flowing cold water from 10 to 21° C. (50 to 70° F.) so that the hot end of the brick will be immersed to a depth of 2 in. After three minutes the sample shall be withdrawn from the water, allowed to steam five minutes and then returned to the furnace. The door of the furnace shall be closed while the bricks are out to prevent the lowering of the temperature. The alternate heating and cooling shall be continued in hourly cycles until a loss of 20 per cent by weight has occurred in each brick.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. C. E. Bales, **Secretary of Committee C-8** on Refractories, Ironton Fire Brick Co., Ironton, Ohio.

(*b*) When pieces begin to fall off, the sample shall be laid on a 4.5 by 9.0-in. asbestos board, divided into 50 equal squares, and the approximate percentage of loss estimated after each removal from the water. After the completion of the test, the brick shall again be weighed and the percentage of loss determined.

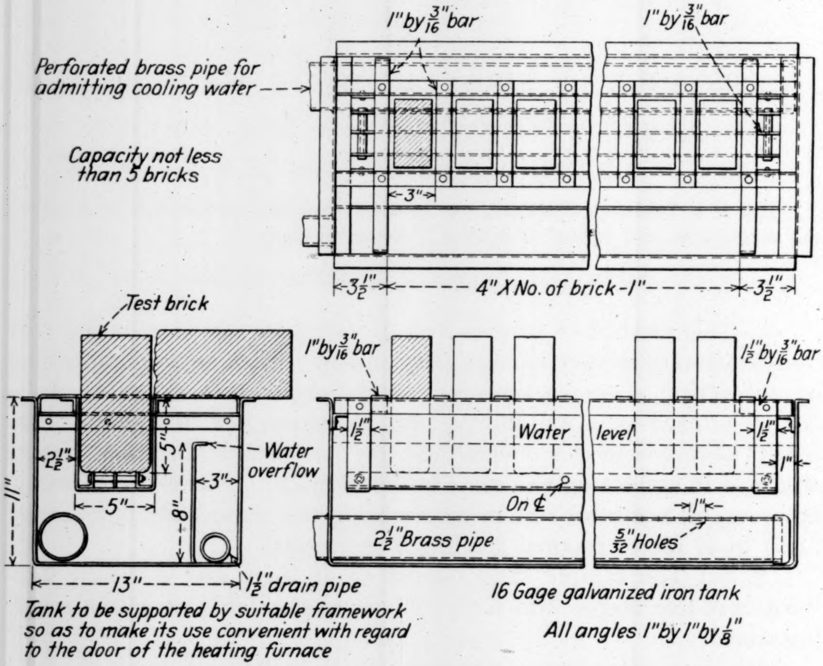
1"by 3/16" bar
1"by 3/16" bar
Perforated brass pipe for admitting cooling water
Capacity not less than 5 bricks
3"
3½"
4"X No. of brick-1"
3½"
Test brick
1"by 3/16" bar
1½"by 3/16" bar
11"
2½"
5"
5"
8"
3"
Water overflow
1½"
Water level
1½"
1"
On ℄
1"
2½" Brass pipe
5/32" Holes
13"
1½" drain pipe
Tank to be supported by suitable framework so as to make its use convenient with regard to the door of the heating furnace
16 Gage galvanized iron tank
All angles 1"by 1"by 1/8"

FIG. 1.—Apparatus for Cooling Brick in Spalling Test.

Reporting Results. 4. The report shall show for each brick the number of dips before loss started, the percentage of loss after each cooling and the total number of dips until a loss of 20 per cent by weight has occurred.

TENTATIVE SPECIFICATIONS
FOR
CLAY SEWER PIPE[1]

A.S.T.M. Designation: C 13 – 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED AS TENTATIVE, 1917; ADOPTED IN AMENDED FORM, 1920; REVISED, 1924; REISSUED AS TENTATIVE, 1932; REVISED, 1933.[2]

Scope. 1. These specifications cover clay products intended to be used for the conveyance of sewage, industrial wastes and storm water.

Single Class. 2. Sewer pipes furnished under these specifications shall be of single class to be designated "A.S.T.M. Clay Sewer Pipe."

MATERIAL AND MANUFACTURE

Materials. 3. (*a*) Clay pipes shall be manufactured from surface clay, fire clay, or shale, or a combination of these materials.

(*b*) *Surface clay* is an unconsolidated, unstratified clay,[3] occurring on the surface.

(*c*) *Fire clay* is a sedimentary clay[3] of low flux content.

NOTE.—It is usually associated with coal measures.

(*d*) *Shale* is a thinly stratified, consolidated sedimentary clay[3] with well marked cleavage parallel to the bedding.

(*e*) These materials or any combination thereof, when molded into pipe and subjected to suitable temperatures, shall produce a product that will be strong, durable, serviceable, free from objectional defects and shall conform to these specifications.

RESISTANCE TO ACTION OF ACIDS

Resistance to Action of Acids. 4. The consumer or purchaser may prescribe in advance the following tests as to the resistance of clay sewer pipe to the action of acids:

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. G. C. D. Lenth, Secretary of Committee C-4 on Clay Pipe, Clay Products Assn., 111 W. Washington St., Chicago, Ill.

These specifications are in effect a revision of and replace the former Standard Specifications for Clay Sewer Pipe (A.S.T.M. Designation: C 13 – 24) which standard was accordingly discontinued in 1933.

[2] Revision accepted by Committee E-10 on Standards, August 16, 1933.

[3] The definitions for the terms "surface clay," "fire clay," and "shale" are based upon the following definition for the term "clay":

Clay.—An earthy or stony mineral aggregate consisting essentially of hydrous silicates of alumina, plastic when sufficiently pulverized and wetted, rigid when dry and vitreous when burned at a sufficiently high temperature.

5. When tested with either hydrochloric, nitric, sulfuric, or acetic acid, the acid having a normality of one (1.0 *N*),[1] the percentage of acid-soluble matter shall not exceed 0.25 per cent, calculated as sulfates. The purpose of this test is to determine the resistance of pipe to the action of acids and its use is optional.

Test Specimens.

6. (*a*) Where possible the specimens intended for these tests shall be selected from pipe which have previously been subjected to the crushing strength test. Specimens shall be sound with all edges freshly broken, free from cracks or shattered edges, about 2 in. square, not weighing more than 200 g. and shall be thoroughly cleaned with a wire brush.

Number of Tests.

(*b*) A test shall be made on at least one specimen cut from each size of pipe. The results shall be reported separately for each individual specimen.

Weighing Apparatus.

7. The weighing shall be made on a balance accurate to 0.01 g. when loaded with 200 g.

Test Procedure.

8. (*a*) The specimens to be tested shall be dried to constant weight at a temperature of from 210 to 230° F.

(*b*) The specimens upon reaching constant weight shall be completely immersed in the test solution at a temperature of from 70 to 90° F. for a period of 48 hours then removed from the solution, carefully and thoroughly washed with hot water, allowing the washings to run into the solution in which the specimen was immersed. This solution shall be filtered and to the filtrate shall be added 5 ml. of concentrated sulfuric acid. This solution shall then be evaporated (avoiding loss by spattering) to about 5 ml.; transferred to a porcelain crucible (previously ignited to constant weight) and heated cautiously to dryness. It shall then be ignited to constant weight.

(*c*) *Calculation.*—The weight of the residue in the porcelain crucible divided by the weight of the dry specimen before immersion multiplied by 100 is the percentage of acid-soluble matter calculated as sulfates.

$$\text{Percentage acid-soluble matter} = \frac{\text{Wt. of residue in grams} \times 100}{\text{Wt. of dry specimen in grams}}$$

PHYSICAL PROPERTIES AND TESTS

Physical Requirements.

9. The crushing strength and absorption of clay sewer pipe shall conform to the requirements given in Table I. The individual results of the various tests for each size of pipe and for each shipment shall be tabulated separately so as to show the percentage which fails to conform to the requirements of each test.

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[1] The following percentages are required to make an acid of a normality of one: sulfuric acid, 4.90 per cent; hydrochloric acid, 3.65 per cent; nitric acid, 6.30 per cent; and acetic acid, 6.00 per cent.

Test Specimens.

10. (*a*) The specimens for purpose of test shall be sound full-size pipe and shall be selected by the purchaser or his representative at a point or points designated by him when placing the order.

Number of Tests.

(*b*) The manufacturer or seller shall furnish specimens for test, without charge, up to 0.5 per cent of the number of pipes in each size of pipe furnished, except that in no case shall less than two specimens be furnished.

Measurement and Observation of Specimens.

11. (*a*) The specimens shall first be freed from all visible moisture. When dry, each specimen shall be weighed, measured and inspected. The results of these observations shall be recorded.

(*b*) *Defective Specimens.*—Specimens which are observed to have fire cracks or other defects in form or dimensions, in excess of the limits permitted in these specifications, shall be discarded and replaced with additional specimens from the shipment.

TABLE I.—PHYSICAL TEST REQUIREMENTS OF CLAY SEWER PIPE.

Internal Diameter, in.	Average Crushing Strength, minimum, lb. per linear foot		Average Absorption, maximum, per cent
	Three-Edge-Bearing Method[1]	Sand-Bearing Method[2]	
4	1000	1430	8
6	1000	1430	8
8	1000	1430	8
10	1100	1570	8
12	1200	1710	8
15	1370	1960	8
18	1540	2200	8
21	1810	2590	8
24	2150	3070	8
27	2360	3370	8
30	2580	3690	8
33	2750	3930	8
36	3080	4400	8

[1] See Section 14.

[2] See Section 15.

Crushing Strength Tests

Crushing Strength Tests.

12. Pipe shall be tested for crushing strength by either the three-edge-bearing method or by the sand-bearing method. Either of the two specified bearing methods shall be used on retests as provided for in Section 20 (*a*) and (*b*).

Application of Load.

13. (*a*) Any prime mover or hand power which will apply the load at a uniform rate of about 2000 lb. per minute, or in increments of not more than 100 lb. at the same rate, may be used in making the test.

(*b*) The center of the load shall be applied to the top bearing block at a point distant from the spigot end of the pipe equal to one-half of the overall length of the pipe. The test load shall be applied to the upper bearing block in such a way as to leave the bearing free to move in a vertical plane passing midway between the lower bearings. In testing pipe that is "out of straight" the lines of the bearings chosen shall be from those which appear to give most favorable conditions for fair test.

(*c*) The pipe shall not be allowed to stand under load longer than is required to apply the load and to observe and record it.

(*d*) The testing machine shall be substantial and rigid throughout, so that the distribution of the load will not be affected appreciably by the deformation or yielding of any part. The bearings shall be sufficiently rigid to transmit and receive uniform loads throughout their lengths without deflection, and shall be so attached to the machine as to transmit and receive the maximum loads produced by the tests without lost motion, vibration or sudden shock.

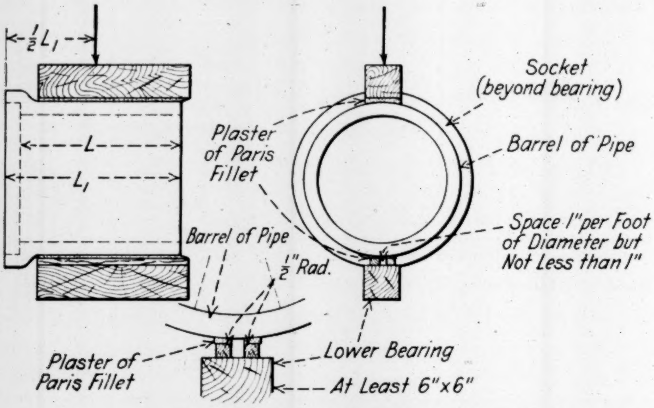
$\frac{1}{2}L_1$
L
L_1
Plaster of Paris Fillet
Socket (beyond bearing)
Barrel of Pipe
Space 1" per Foot of Diameter but Not Less than 1"
Barrel of Pipe
½" Rad.
Plaster of Paris Fillet
Lower Bearing
At Least 6"x6"

FIG. 1.—Three-Edge Bearings.

(*e*) The bearings and the specimen shall be accurately centered so as to secure a symmetrical distribution of the loading on each side of the center of the pipe in every direction.

(*f*) The load shall be applied until the pipe yields by cracks passing through the shell.

(*g*) The crushing strength shall be calculated by dividing the total load required to break each pipe by the net inside length of the barrel of the pipe, measuring from the bottom of the socket to the end of the spigot.

Three-Edge-Bearing Method.

14. When the three-edge-bearing method (see Fig. 1) is used, the ends of each specimen of pipe shall be accurately marked in halves of the circumference prior to the test. The two lower bear-

ings shall consist of two wooden strips with vertical sides having their interior top corners rounded to a radius of approximately ½ in. The strips shall be straight and shall be securely fastened to a rigid block at least 6 by 6 in. in cross-section. The interior vertical sides of the strips shall be parallel and a distance apart of 1 in. per foot of pipe diameter but in no case less than 1 in. Before the pipe is placed, a fillet of plaster of Paris thick enough to compensate for all the inequalities of the pipe barrel shall be cast on and between the two lower bearings. The pipe shall be placed on the fillet while the plaster of Paris is still somewhat plastic, the use of the plaster of Paris fillet may be dispensed with when mutually agreeable to the manufacturer and the purchaser. The upper bearing shall be a rigid wooden block at least 6 by 6 in. in cross-section, straight and true from end to end. A fillet of plaster of Paris thick enough to compensate for the inequalities of the pipe barrel shall also be cast along the length of the crown. The upper bearing shall be brought in contact while the plaster of Paris is still somewhat plastic. The upper and lower bearings shall extend the full length of the pipe exclusive of socket.

Sand-Bearing Method.

15. When the sand-bearing method (see Fig. 2) is used the ends of each specimen of pipe shall be accurately marked in quarters of the circumference prior to the test. Specimens shall be carefully bedded, above and below, in sand, for one-fourth the circumference of the pipe measured on the middle line of the barrel. The depth of bedding above and below the pipe at the thinnest points shall be one-half the radius of the middle line of the barrel.

The sand used shall be clean and moist, and shall be such as will pass a 4760-micron (No. 4) sieve.[1] The sand in the lower bearing shall be loose when the pipe is placed.

The top bearing frame shall not be allowed to come in contact with the pipe nor with the top bearing plate. The upper surface of the sand in the top bearing shall be struck off level with a straight edge, and shall be covered with a rigid top bearing plate, with lower surface a true plane, made of heavy timbers or other rigid material, capable of distributing the test load uniformly without appreciable bending. The test load shall be applied at the exact center of this top bearing plate, in such a manner as to permit free motion of the plate in all directions. For this purpose a spherical bearing is preferred, but two rollers at right angles may be used. The test may be made without the use of a testing machine, by piling weights directly on a platform resting on the top bearing plate, provided, however, that the weights shall be piled symmetrically about a vertical line through the center of the pipe, and that the platform shall not be allowed to touch the top bearing frame.

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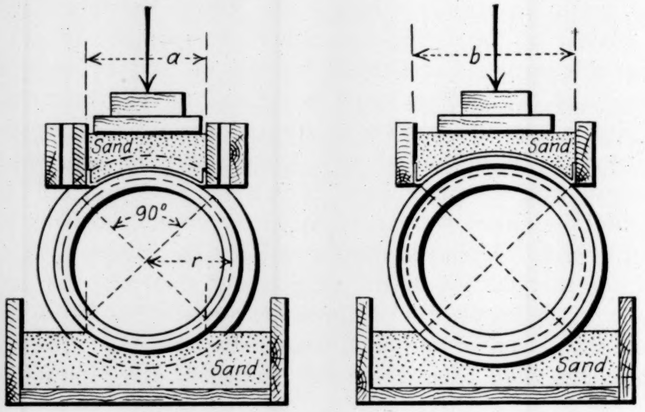
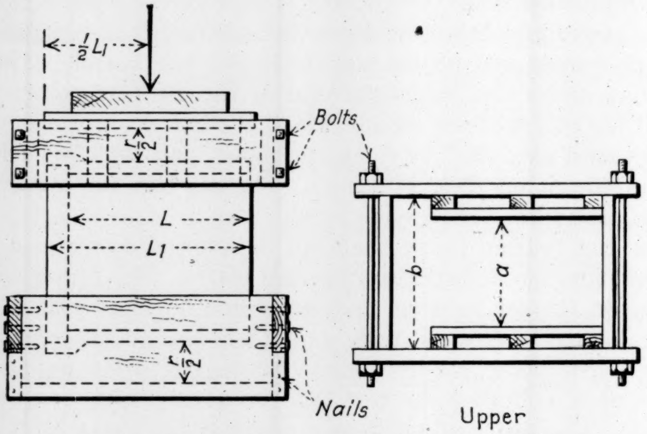
[1] For requirements for this sieve, see Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials, 1933 Book of A.S.T.M. Standards, Part II, p. 1244.



Bedding of Barrel.

Bedding of Socket.



Side View.

Upper Bearing Frame.

FIG. 2.—Sand Bearings.

The frames of the top and bottom bearings shall be made of timbers so heavy as to avoid appreciable bending by the side pressure of sand. The interior surfaces of the frames shall be dressed. No frame shall come in contact with the pipe during the test. A strip of cloth may, if desired, be attached to the inside of the upper frame on each side, along the lower edge, to prevent the escape of sand between the frame and the pipe.

Absorption Test

Test Specimens.

16. (*a*) The specimens shall be sound pieces, with all edges broken, and may be from pipes broken in the crushing strength tests. They shall be from 12 to 20 sq. in. in area, and shall be as nearly square as they can be readily prepared. They shall be free from observable cracks, fissures, laminations or shattered edges.

Identification.

(*b*) Each specimen shall be marked so that it may be identified with the pipe used in the crushing strength test from which the specimen was taken. The marking shall be applied so that the pigment used shall not cover more than 1 per cent of the total superficial area of the specimen.

Number of Tests.

(*c*) One specimen shall be tested of each pipe broken in the crushing strength test.

Weighing Apparatus.

17. The balance used shall be sensitive to 0.5 g. when loaded with 1 kg., and weighings shall be read to the nearest 1 g. When other than metric weights are used, the same degree of accuracy shall be obtained.

Procedure.

18. (*a*) *Drying.*—Preparatory to the absorption test, the specimen shall be brought to constant weight in a drier or oven at a temperature of not less than 110° C. (230° F.).

(*b*) *Immersion.*—After reaching constant weight, the specimen shall be placed with other similar specimens in a suitable wire receptacle, packed tightly enough to prevent jostling, covered with distilled water or rainwater, raised to the boiling point and boiled for five hours, and then cooled in water to a final temperature of 15 to 25° C. (59 to 77° F.).

(*c*) *Reweighing.*—The specimen shall be allowed to drain for one minute, and the superficial moisture having been removed by towel or blotting paper, placed upon the balance and weighed.

Calculation and Reporting of Results.

19. The absorption shall be calculated as percentage of the initial dry weight. The results shall be reported separately for each individual specimen, together with the mean for all the specimens from the same shipment of pipe.

Acceptance or Rejection on Results of Test.

20. (*a*) Failure of 20 per cent of the specimens to meet the requirements of crushing strength and/or absorption tests shall result in rejection of all the pipe in the shipment or delivery, corresponding to the sizes thus failing to comply; except that in the event of 20 per cent of the specimens in any size failing to meet the requirements,

the manufacturer or seller may, with the consent of the purchaser, furnish for test, without charge, additional specimens from the same shipment. In case more than 80 per cent of the specimens tested, including those first tested, shall show substantial conformance for each of the various tests performed, then the entire shipment or delivery for this size shall be accepted; otherwise it shall be rejected.

(*b*) However, in case of failure of pipe to meet the requirements under the specified method, especially where the accuracy of the testing machine is questioned, a retest at the request of the manufacturer shall be made upon a machine whose accuracy is known or that the machine originally used be recalibrated before the retest is made.

(*c*) In addition to the requirements in Paragraph (*a*), failure of 10 per cent or more of the individual specimens tested to develop 75 per cent of the average crushing strength requirements shall be cause for the rejection of the shipment, but the manufacturer or seller may cull the pipe and submit the balance of the shipment for retest, and if the shipment then conforms to all of the requirements of these specifications it shall be accepted.

A.S.T.M. SIZES, DIMENSIONS AND PERMISSIBLE VARIATIONS

Sizes and Dimensions.

21. Pipes shall be furnished of the sizes, internal diameter, and with the dimensions given in Table II. Where several lengths are mentioned in the table the consumer or purchaser shall indicate, at the time of purchase, which lengths shall be furnished; and unless so indicated, the manufacturer shall furnish such lengths as he may elect.

Permissible Variations.

22. The permissible variations from the dimensions given in Table II shall not exceed those specified in Table III. Where the average diameter in the spigot is larger than the nominal size, the average diameter at inside of the socket shall be increased by the same amount. Where the thickness of barrel is increased beyond that given in Table III in order to meet the specified requirements of strength, the diameter at inside of socket shall be increased by double the increase in thickness of barrel. Pipes intended to be straight shall not have variation in alignment of more than $\frac{1}{8}$ in. per foot of length. This measurement to mean the maximum ordinate as measured from the concave side of the pipe.

WORKMANSHIP AND FINISH

Absence of Defects.

23. Pipes shall be substantially free from fractures, large or deep cracks and blisters, laminations and surface roughness.

Salt Glaze. 24. The glaze shall consist of a continuous layer of salt glaze substantially free from large blisters or large pimples. No blisters shall exceed 3 in. in diameter and no blisters or pimples shall project more than $\frac{1}{8}$ in. above the surrounding surface of the pipe for sizes up to and including 18 in. internal diameter. For sizes over 18 in. internal diameter no blisters shall exceed in diameter more than 2 in. per foot

TABLE II.—DIMENSIONS OF CLAY SEWER PIPE.[a]

Internal Diameter (D), in.	Laying Length (L), ft.	Inside Diameter at $\frac{1}{2}$ in. Above Base of Socket (D_S), in.[b,c]	Depth of Socket (L_S), in.	Minimum Taper of Socket (H)	Thickness of Barrel (T), in.	Thickness of Socket (T_S)
4	2	$5\frac{3}{4}$	$1\frac{3}{4}$	1:20	$\frac{1}{2}$	The thickness of the socket $\frac{1}{4}$ in. from its outer end shall be not less than three-fourths of the thickness of the barrel of the pipe.
6	2, $2\frac{1}{2}$	$8\frac{1}{4}$	$2\frac{1}{4}$	1:20	$\frac{5}{8}$	
8	2, $2\frac{1}{2}$, 3	$10\frac{1}{2}$	$2\frac{1}{2}$	1:20	$\frac{3}{4}$	
10	2, $2\frac{1}{2}$, 3	$12\frac{3}{4}$	$2\frac{1}{2}$	1:20	$\frac{7}{8}$	
12	2, $2\frac{1}{2}$, 3	$15\frac{1}{8}$	$2\frac{3}{4}$	1:20	1	
15	2, $2\frac{1}{2}$, 3	$18\frac{3}{4}$	$2\frac{3}{4}$	1:20	$1\frac{1}{4}$	
18	2, $2\frac{1}{2}$, 3	$22\frac{1}{2}$	3	1:20	$1\frac{1}{2}$	
21	2, $2\frac{1}{2}$, 3	$25\frac{3}{4}$	$3\frac{1}{4}$	1:20	$1\frac{3}{4}$	
24	2, $2\frac{1}{2}$, 3	$29\frac{3}{8}$	$3\frac{3}{8}$	1:20	2	
27	$2\frac{1}{2}$, 3	$33\frac{1}{8}$	$3\frac{1}{2}$	1:20	$2\frac{1}{4}$	
30	$2\frac{1}{2}$, 3	$36\frac{5}{8}$	$3\frac{1}{2}$	1:20	$2\frac{1}{2}$	
33	$2\frac{1}{2}$, 3	40	4	1:20	$2\frac{5}{8}$	
36	$2\frac{1}{2}$, 3	$43\frac{1}{4}$	4	1:20	$2\frac{3}{4}$	

[a] Applications of dimensions given in this table are shown in Fig. 3.

[b] When pipes are furnished having an increase in thickness over that given in last column, the diameter of socket shall be increased by an amount equal to twice the increase of thickness of barrel.

[c] When the pipes furnished have an average diameter larger than the nominal size, the inside diameter of the socket shall be greater by the same amount than the values given in the third column.

TABLE III.—PERMISSIBLE VARIATIONS IN DIMENSIONS OF CLAY SEWER PIPE.

Nominal Size, Internal Diameter, in.	Limits of Permissible Variation in:					
	Length, in. per ft. (−)	Lengths of Two Opposite Sides, in. per foot of length	Internal Diameter, in.		Depth of Socket, in. (−)	Thickness of Barrel, in. (−)
			Spigot (±)	Socket (±)		
4	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{1}{16}$
6	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{16}$
8	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{1}{4}$	$\frac{1}{16}$
10	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{1}{4}$	$\frac{1}{16}$
12	$\frac{1}{4}$	$\frac{3}{16}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{1}{4}$	$\frac{1}{16}$
15	$\frac{1}{4}$	$\frac{3}{16}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{1}{4}$	$\frac{3}{32}$
18	$\frac{1}{4}$	$\frac{3}{16}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{3}{32}$
21	$\frac{1}{4}$	$\frac{3}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{1}{4}$	$\frac{1}{8}$
24	$\frac{3}{8}$	$\frac{1}{4}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{1}{4}$	$\frac{1}{8}$
27	$\frac{3}{8}$	$\frac{1}{4}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{1}{4}$	$\frac{1}{8}$
30	$\frac{3}{8}$	$\frac{1}{4}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{1}{4}$	$\frac{1}{8}$
33	$\frac{3}{8}$	$\frac{1}{4}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{1}{4}$	$\frac{3}{16}$
36	$\frac{3}{8}$	$\frac{1}{4}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{1}{4}$	$\frac{3}{16}$

NOTE.—The minus sign (−) alone indicates that the plus variation is not limited, the plus and minus sign (±) indicates variation in both excess and deficiency in dimension.

of the internal diameter of the pipe, nor project above the surrounding surface of the pipe more than $\frac{1}{8}$ in. per foot of the internal diameter of the pipe.

Not more than 10 per cent of the inner surface of any pipe barrel shall be bare of glaze except the socket, where it may be entirely absent. Glazing shall not be required on the outer surface of the barrel at the spigot end for a distance from the end of the pipe equal to the specified depth of socket. There shall be no well defined network of crazing lines or hair cracks.

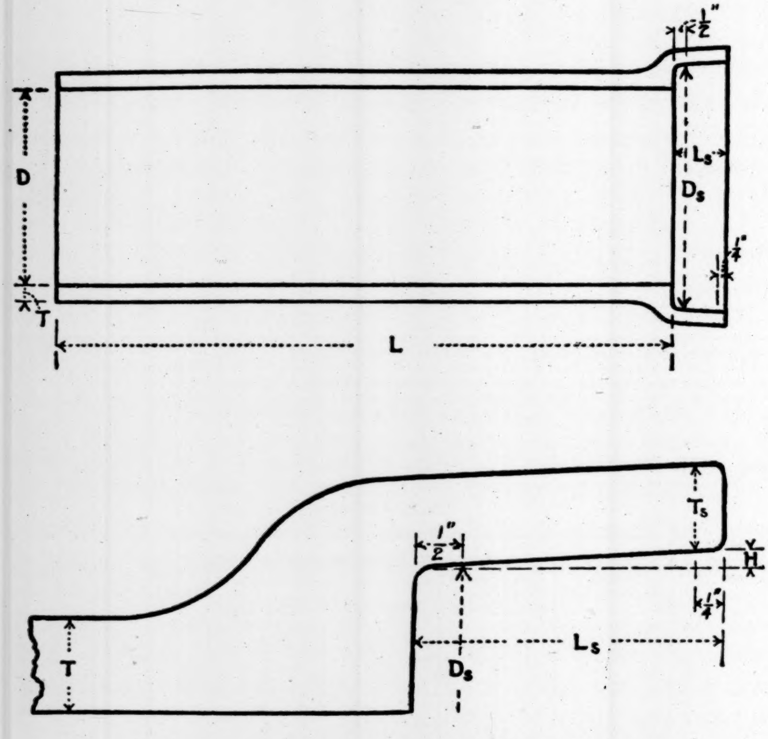


FIG. 3.—Applications of Dimensions Given in Table II.

Finish of Ends. 25. The ends of the pipes shall be square with their longitudinal axis, except as provided in Table III.

Fittings. 26. (*a*) Fittings shall have a plain spigot end and a socket end corresponding in all respects with the dimensions specified for pipes of the corresponding internal diameter. Branch pipes shall be furnished to lay the same lengths as straight pipe. All fittings shall conform in finish to the specifications for pipe given in Sections 23, 24, and 25.

(*b*) Slants shall have their spigot ends cut at an angle of approximately 60 deg. with the longitudinal axis.

(*c*) Curves shall be at angles of 90 and 45 deg., as required. They shall conform substantially to the curvature specified.

(*d*) Branches shall be furnished with the spur or spurs of the size or sizes specified, securely and completely fastened in the process of manufacture, to the barrel of the pipe. T-branches and double T-branches shall have their axes perpendicular to the longitudinal axis of the pipe. Y-branches and double Y-branches shall have their axes approximately 60 deg. from the longitudinal axis of the pipe measured from the socket end. All spurs shall terminate in sockets and the barrel of the spurs shall be of sufficient length to permit making a proper joint when the connecting pipe is inserted in the spur socket.

(*e*) Channel or split pipes, curves and branches shall be approximate half sections of the corresponding size of straight pipe and fittings.

MARKING

Marking.

27. All pipe over 6 in. in diameter shall bear the initials or name of the person, company or corporation by whom manufactured, and the location of the mill. The markings shall be indented on the exterior of the pipe near the socket and shall be plainly legible for purposes of identification.

INSPECTION AND REJECTION

Inspection.

28. All pipes shall be subject to inspection at the factory, trench or other point of delivery by a competent inspector employed by the purchaser. The purposes of the inspection shall be to cull and reject pipes which, independent of the physical tests herein specified, fail to conform to the requirements of these specifications.

Rejection.

29. Pipes shall be subject to rejection on account of the following:

(*a*) Variations in any dimension exceeding the permissible variations given in Table III.

(*b*) Fractures or cracks passing through the shell or socket, except that a single crack at the spigot end of the pipe not exceeding 75 per cent of the depth of the socket, or a single fracture in the socket not exceeding 3 in. in width nor 2 in. in length.

(*c*) Chips or fractures on the interior of the pipe exceeding 2 in. in length, 1 in. in width, and of a depth more than one-quarter of the thickness of the shell.

(*d*) Blisters which are broken or which exceed the dimensions specified in Section 24.

(*e*) Fire cracks or hair cracks sufficient to impair the strength, durability or serviceability of the pipe.

(*f*) Variation of more than $\frac{1}{8}$ in. per linear foot in alignment of a pipe intended to be straight.

(*g*) Glaze which does not conform with these specifications as specified in Section 24.

(*h*) Insecure attachment of spurs on branches.

Marking of Rejected Specimens. 30. All pipes accepted may be plainly marked by the inspector. Rejected pipes shall not be marked so as to be defaced or to impair their value, but shall be replaced by the manufacturer or seller with pipes which meet the requirements of these specifications, without additional cost to the purchaser.

NOTE.—Attention is called to the Standard Definitions of Terms Relating to Sewer Pipe (A.S.T.M. Designation: C 8) and Recommended Practice for Laying Sewer Pipe (A.S.T.M. Designation: C 12) of the American Society for Testing Materials, see 1933 Book of A.S.T.M. Standards, Part II, pp. 218, 222.

TENTATIVE SPECIFICATIONS
FOR
READY MIXED CONCRETE[1]

A.S.T.M. Designation: C 94 – 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1933.

Scope

1. These specifications cover requirements for the materials, proportioning, mixing, delivery, quality, inspection, testing, and acceptance of ready mixed concrete for all purposes.

Ready Mixed Concrete

2. The term ready mixed concrete is used to describe mixed concrete delivered at the work ready for use.

MATERIALS

General

3. Ready mixed concrete shall consist of a mixture of portland cement, aggregates and water, proportioned in accordance with the requirements of these specifications. Admixtures may be included with these primary ingredients when specified by, or with the permission of, the purchaser.

Cement

4. (*a*) Portland cement shall conform to the requirements of the Standard Specifications for Portland Cement (A.S.T.M. Designation: C 9) of the American Society for Testing Materials.[2]

(*b*) High-early-strength portland cement shall conform to the requirements of the Tentative Specifications for High-Early-Strength Portland Cement (A.S.T.M. Designation: C 74 – 30 T) of the American Society for Testing Materials.[3]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. R. R. Litehiser, Secretary of Committee C-9 on Concrete and Concrete Aggregates, Ohio State Highway Testing Laboratory, Ohio State University, Columbus, Ohio.

[2] 1933 Book of A.S.T.M. Standards, Part II, p. 3.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 1016; also 1933 Book of A.S.T.M. Tentative Standards, p. 297.

Aggregates

5. (*a*) Aggregates shall conform to the requirements of the Tentative Specifications for Concrete Aggregates (A.S.T.M. Designation: C 33 – 31 T) of the American Society for Testing Materials.[1]

(*b*) Frozen aggregates, or aggregates containing lumps of frozen material, shall be thawed before use.

Water

6. Water shall be free from injurious amounts of impurities. Potable water shall be considered as meeting the requirements of these specifications.

COMPOSITION OF CONCRETE

General

7. The size and type of aggregate and the quality and consistency of the concrete required for the work shall be specified by the purchaser. The manufacturer of ready mixed concrete shall determine the quantities of materials for the batch to produce concrete of the quality and consistency specified. The consistency shall be determined by the slump test, referred to in Section 26 (*a*), unless another method is specified or permitted by the purchaser.

Proportions by Volume

8. When the quality of the concrete is specified in terms of the consistency and arbitrary proportions by volume, 1 cu. ft. of cement shall be considered to weigh 94 lb., and, unless another basis is specified by the purchaser, the weight per unit of volume of the aggregates shall be based on rodded weights determined on surface-dried materials, in accordance with the Standard Method of Test for Unit Weight of Aggregate for Concrete (A.S.T.M. Designation: C 29) of the American Society for Testing Materials.[2]

Proportions by Weight

9. When the quality of the concrete is specified in terms of the consistency and arbitrary proportions by weight, the weights of the aggregates shall be stated in terms of surface-dried materials.

Proportions in Terms of Quantity of Cement

10. When the quality of the concrete is specified in terms of the consistency and the quantity of cement per unit of volume of concrete, 1 cu. ft. of cement shall be considered to weigh 94 lb., and the ratio by weight of the fine aggregate to the fine plus coarse aggregate shall

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 750 (1931); also 1933 Book of A.S.T.M. Tentative Standards, p. 412.

[2] 1933 Book of A.S.T.M. Standards, Part II, p. 247.

be such as to produce a plastic and workable mixture and shall not be greater than 0.55, unless otherwise specified by the purchaser; except that this ratio may not apply to light-weight aggregates. Under this clause the proportions of cement to aggregate shall not be stated.

Proportions Based on Water-Cement Ratio

11. When the quality of the concrete is specified in terms of the consistency and the ratio of quantity of mixing water to quantity of cement, the water shall include that added to the batch and the surface moisture of the aggregates, and the ratio of fine to coarse aggregate shall be such as to produce a plastic and workable mixture. Under this clause the proportions of cement to aggregate shall not be stated, except that a minimum cement content may be specified.

Proportions Based on Strength

12. When the quality of the concrete is specified in terms of the consistency and the compressive or flexural strength, at an age specified by the purchaser, the ratio of fine to coarse aggregate shall be such as to produce a plastic and workable mixture. Under this clause the proportions of cement to aggregate shall not be stated, except that a minimum cement content may be specified.

MEASURING MATERIALS

Cement

13. Cement shall be measured by weight or, if permitted by the purchaser, in full bags of 94 lb. each. When the cement is measured by weight, it shall be weighed on a scale separate from those used for the other materials; when the cement is measured in bags, no fraction of bags shall be used, unless weighed.

Aggregates

14. Coarse aggregates shall be measured by weight. Fine aggregates shall be measured by weight or by inundated volume in a device suitable to the purchaser. Batch weights shall be based on surface-dried materials and shall be corrected to take into account the weight of surface moisture contained in the aggregates.

Water

15. Water shall be measured by volume or by weight. The device for the measurement of the water shall be readily adjustable and, under all operating conditions, shall be accurate to 0.5 per cent or less of its maximum capacity.

Admixtures

16. Powdered admixtures shall be measured by weight and liquid admixtures by weight or volume.

Weighing Hoppers and Scales

17. Weighing hoppers and scales shall conform to the Specifications and Tolerances of the American Road Builders' Association for the Bin Batcher Type of Equipment for Weighing Concrete Aggregates.[1,2]

MIXING

General

18. The mixing equipment shall be capable of combining the aggregates, cement, and water within the specified time into a thoroughly mixed and uniform mass, and of discharging the mixture without segregation.

Central Mixing Plant

19. In the case of the stationary mixers, the mixer drum shall be of adequate size to accommodate the maximum batch, and shall be in accordance with the Concrete Mixer Standards adopted by the Mixer Manufacturers' Bureau of the Associated General Contractors of America. The mixer shall be rotated at the rate recommended by its manufacturer. Provision shall be made at the mixer to insure that the concrete is not discharged until the specified mixing time has elapsed. The mixing time shall be measured from the time that all dry materials are in the mixer. The batch shall be so charged into the mixer that some water shall enter in advance of cement and aggregate, and shall continue to flow for a period which may extend to the end of the first one third of the specified mixing time. When the central mixing plant is depended upon for the complete mixing, the minimum mixing time for mixers of 1-cu.-yd. capacity or less shall be 1 minute; for larger capacities of mixers this mixing time shall be increased at the rate of 15 seconds for each cubic yard, or fraction thereof, additional capacity. When the concrete is transported in an agitator, the size of batch shall not exceed the rated capacity of the agitator as stated by the manufacturer, and as stamped in metal at a prominent place on the equipment. When the agitator is provided with mixing blades, the mixing time at the central mixer may be reduced to the minimum required to incorporate the ingredients of the mixture into a mass and the mixing completed in the agitator; under these circumstances all ingredients for a batch shall

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[1] Am. Road Builders' Assn., *Bulletin 15*, Section I, Part 1 (1931).

[2] The essential requirements outlined in *Bulletin 15* have been adopted by the American Association of State Highway Officials.

be in the mixer and properly incorporated before any concrete is discharged to the agitator and each batch of concrete shall be mixed in the agitator for 50 revolutions or more.

Truck Mixing

20. In the case of truck mixers, the size of batch shall not exceed the rated capacity of the mixer as stated by the manufacturer and as stamped in metal at a prominent place on the mixer. The mixer shall be water-tight when closed. Each batch of concrete shall be mixed not less than 50 nor more than 150 revolutions of the mixer at the rate of rotation specified by the manufacturer as mixing speed. Any additional mixing shall be done at a slower speed specified by the manufacturer for agitation. The truck mixer shall be equipped with a tank for carrying the mixing water; the water shall be measured and placed in the tank at the proportioning plant, unless the tank is equipped with an automatic measuring device of the required accuracy and capable of being locked. The mixing water may be added directly to the batch, except as limited by Section 22.

DELIVERY

General

21. Concrete shall be hauled in a water-tight container in which segregation will not take place and from which the concrete can be discharged freely and shall be delivered to the work at the consistency specified.

Time of Hauling

22. Concrete shall be delivered to the site of the work, and discharge from the hauling container shall be begun within a period of $1\frac{1}{2}$ hr. after the introduction of the mixing water to the dry materials, or the cement to the aggregate if the fine aggregate contains surface moisture in excess of 6 per cent by weight or the coarse aggregate contains surface moisture in excess of 3 per cent by weight.

Temperature

23. Concrete delivered in out-door temperatures lower than 40 F. (5 C.) shall arrive at the work having a temperature not less than 60 F. (15 C.), nor greater than 100 F. (38 C.), unless otherwise specified or permitted by the purchaser.

INSPECTION

General

24. Proper facilities shall be provided for the purchaser to inspect ingredients and processes used in the manufacture of the concrete

either at the mixing plant, loading plant or point of delivery. The manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities for securing samples to determine if the concrete is being furnished in accordance with these specifications. All tests and inspections shall be so conducted as not to interfere unnecessarily with the manufacture and delivery of the concrete.

Samples

25. (*a*) Samples of concrete taken for the purpose of determining if the concrete conforms to the requirements of these specifications shall be secured at the point of delivery during the discharge of the batch.

(*b*) Each sample of concrete for strength tests shall consist of not less than one cubic foot made up of portions obtained from not less than three points within the batch.

METHODS OF TESTING

Methods of Testing

26. Tests of the concrete shall be carried out in accordance with the following methods of the American Society for Testing Materials:

(*a*) *Consistency.*—The consistency of the concrete, unless otherwise specified or permitted by the purchaser, shall be measured by the slump determined in accordance with the Tentative Method of Test for Consistency of Portland-Cement Concrete (A.S.T.M. Designation: D 138 – 32 T).[1]

(*b*) *Compression Tests.*—Compression test specimens of concrete shall be molded, cured, and tested in accordance with the Standard Method of Making and Storing Compression Test Specimens of Concrete in the Field (A.S.T.M. Designation: C 31),[2] except that Section 7 (*b*) shall not apply for specimens used as the basis for acceptance.

(*c*) *Flexure Tests.*—Flexure test specimens of concrete shall be molded and tested in accordance with the Tentative Laboratory Method of Making Flexure Tests of Concrete, Using a Simple Beam with Center Loading (A.S.T.M. Designation: C 78 – 30 T).[3] The samples of concrete shall be obtained and the specimens cured in accordance with the method described for compression tests in the Standard Method of Making and Storing Compression Test Specimens of Concrete in the Field (A.S.T.M. Designation: C 31),[1] except that Section 7 (*b*) shall not apply for specimens used as the basis for acceptance.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 775 (1932); also 1933 Book of A.S.T.M. Tentative Standards, p. 641.

[2] 1933 Book of A.S.T.M. Standards, Part II, p. 225.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 027 (1930); also 1933 Book of A.S.T.M. Tentative Standards, p. 440.

ACCEPTANCE AND REJECTION

Consistency

27. (*a*) The concrete shall be considered to have conformed to the consistency requirements of these specifications if the average consistency of three determinations of the slump on a single sample is within 20 per cent of the consistency specified.

(*b*) The slump test for consistency shall be made as often as required by the purchaser.

Strength

28. (*a*) Concrete shall be considered to have conformed to the strength requirements of these specifications if the average strength of all specimens tested is equal to or greater than the strength specified and if the number and concordance of the strength tests conforms to the requirements of Paragraphs (*b*) to (*e*).

(*b*) The number of strength tests shall be determined by the purchaser, except that, if acceptance or rejection is based on Paragraph (*a*), not less than the number of tests shown in the following table shall be made:

TOTAL CUBIC YARDS OF CONCRETE DELIVERED ON JOB	NUMBER OF STRENGTH TESTS
0 to 100	One for each 50 cu. yd.
100 to 1000	One for each 125 cu. yd.
1000 to 2000	One for each 175 cu. yd.
2000 and over	One for each 250 cu. yd.

(*c*) A test shall consist of the average of two or more standard specimens made from a single sample. Results from obviously faulty, defective or improperly cured specimens shall be disregarded in determining the average

(*d*) At least 90 per cent of all strength tests shall be equal to or greater than 90 per cent of the strength specified.

(*e*) The strength tests shall be carried out under the supervision of a qualified engineer mutually agreed upon by both the manufacturer and purchaser.

NOTE.—The question of payment for the strength tests shall form a part of the contract between the purchaser and the manufacturer.

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[1] 1933 Book of A.S.T.M. Standards, Part II, p. 225.

Alternate Strength Basis

29. The provisions of Section 28 may be waived, at the option of the purchaser, if the manufacturer can produce evidence satisfactory to the purchaser that concrete of the proportions proposed for use will furnish the specified strength. Under this clause the concrete shall be considered to have conformed to the requirements for strength if these proportions are maintained throughout the work.

Retest

30. (*a*) When Section 28 is used as the basis for acceptance, if the concrete fails to conform to the requirements of that section, the manufacturer shall have the right to test specimens cut from the structure. Such specimens shall be obtained in accordance with the Standard Methods of Securing Specimens of Hardened Concrete from the Structure (A.S.T.M. Designation: C 42)[1] and tested in accordance with Sections 19, 20 and 21 of the Standard Methods of Making Compression Tests of Concrete (A.S.T.M. Designation: C 39) of the American Society for Testing Materials.[2]

(*b*) Specimens cut from the structure shall be obtained and tested within a period of 60 days after placing the concrete. The specimens shall be tested in a saturated condition and no correction shall be made for the age of the concrete.

(*c*) The tests shall be carried out under the supervision of a qualified engineer mutually agreed upon by both the manufacturer and purchaser, and the costs of the tests shall be borne by the manufacturer.

(*d*) The concrete shall be considered as conforming to the requirements of these specifications if the average strength of the specimens cut from the structure is equal to or greater than the specified strength, and at least 90 per cent of all tests are equal to or greater than 90 per cent of the specified strength.

Measurement of Concrete

31. The basis of measurement of the concrete shall be the cubic yard. The quantity of concrete produced by a given combination of materials may be determined by measurement in a standard measure or may be calculated from the absolute volumes of the separate ingredients as determined from the weight of each used in a batch and its specific gravity. When the latter method is used, proper correction shall be made for the free and absorbed moisture content of the aggregate.

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[1] 1933 Book of A.S.T.M. Standards, Part II, p. 238.

[2] *Ibid.*, p. 230.

TENTATIVE METHOD OF TEST
FOR
ABSORPTION BY AGGREGATES FOR CONCRETE (LABORATORY DETERMINATIONS)[1]

A.S.T.M. Designation: C 95 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1933.

Scope

1. This method of test is intended for use in making laboratory determinations of absorption by fine or coarse aggregate.

Sample

2. The test sample shall be representative and shall weigh approximately 500 g. (1.1 lb.) for fine aggregate, at least 3000 g. (6.6 lb.) for coarse aggregate which contains no pieces larger than 1½ in., or at least 5000 g. (11 lb.) for coarse aggregate containing pieces larger than 1½ in.

Saturation

3. (*a*) *Fine Aggregate.*—The test sample of fine aggregate shall be immersed in clear water at room temperature for 2 hr.

(*b*) *Coarse Aggregate.*—The test sample of coarse aggregate shall be immersed in clear water at room temperature, raised to boiling and boiled continuously for 3 hr., then cooled in water to room temperature.

Surface Drying

4. After saturation, the test sample shall be removed and drained, and then spread on a flat surface and exposed to air (a porous surface and artificial circulation are advantageous, especially for large samples) with stirring until the surface moisture disappears and, in the case of fine aggregate, the material becomes free flowing. Coarse aggregate may, optionally, be rolled in an absorbent towel until

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. R. R. Litehiser, Secretary of Committee C-9 on Concrete and Concrete Aggregates, Ohio State Highway Testing Laboratory, Ohio State University, Columbus, Ohio.

surface dry. To more accurately gage the end point with fine aggregate, the sample shall be placed in a dry quart glass jar and water added drop by drop until the grains just persist in tending to adhere to the glass after thoroughly shaking and mixing the sample.

Weighing

5. After surface drying, the major portion of the prepared saturated surface-dry sample shall be weighed immediately to the nearest 0.05 per cent. It shall then be dried to constant weight at a temperature of 100 to 120 C., cooled to room temperature, and reweighed with the same accuracy.

Calculation

6. The percentage of absorption by the aggregate shall be calculated from the following formula:

$$X = \frac{(S - D)}{D} \times 100$$

where X = the percentage of absorption by the aggregate;
S = the weight of the saturated, surface-dry samples; and
D = the weight of the same sample dried to constant weight.

TENTATIVE METHOD OF FIELD TEST
FOR
ABSORPTION OF MIXING WATER BY AGGREGATES FOR CONCRETE[1]

A.S.T.M. Designation: C 96 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1933.

Scope

1. This method of test is intended for use in making approximate field determinations of the water required to compensate for absorption of mixing water by unsaturated fine or coarse aggregate.

Sample

2. The sample shall be representative of the aggregate in the condition in which it will be used in the batch, particularly as to gradation and moisture content. At least twice as much material should be available as will be needed for the test sample. The material shall be thoroughly mixed and the test sample immediately weighed to the nearest 0.1 per cent. The test sample shall weigh approximately 500 g. (1.1 lb.) for fine aggregate, at least 3000 g. (6.6 lb.) for coarse aggregate which contains no pieces larger than 1½ in., or at least 5000 g. (11 lb.) for coarse aggregate containing pieces larger than 1½ in.

Saturation

3. The test sample shall be immersed in clear water for 30 minutes.

Surface Drying

4. After saturation, the test sample shall be removed and drained, and then spread on a flat surface and exposed to air (a porous surface and artificial circulation are advantageous for larger samples) with stirring until the surface moisture disappears, and in the case of fine aggregate, the sample becomes free flowing. Coarse aggregate may, optionally, be rolled in an absorbent towel until surface drys, but loss of material must be avoided.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. R. R. Litehiser, Secretary of Committee C-9 on Concrete and Concrete Aggregates, Ohio State Highway Testing Laboratory, Ohio State University, Columbus, Ohio.

Weighing

5. After surface drying, the sample shall be weighed immediately to the nearest 0.1 per cent.

Calculation

6. The water required to compensate for absorption of mixing water by each 100 lb. of the unsaturated aggregate shall be calculated from the following formula:

$$X = \frac{(P - O)}{O} \times 100$$

where X = the weight of water in pounds required to compensate for mixing water absorbed per 100 lb. of the unsaturated aggregate;

O = the original weight of the test sample in pounds; and

P = the weight of the same sample in pounds, partially saturated, surface dry.

NOTE.—A negative result indicates that the sample is completely saturated and contains free surface water.

TENTATIVE METHOD OF SAMPLING COKE FOR ANALYSIS[1]

A.S.T.M. Designation: D 346 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

Issued, 1932; Revised, 1933.

It is imperative that every sample be collected and prepared carefully and conscientiously and in strict accordance with the standard procedure described herein, for if the sampling is improperly done, the sample will be in error, and it may be impossible or impracticable to take another sample; whereas if an analysis is in error, another analysis can readily be made of the original sample.

Gross samples of not less than the quantities designated herein must be taken whether the coke to be sampled consists of a few tons or several hundred tons in order to minimize the effect of the chance inclusion or exclusion of too many or too few pieces of non-representative material.

For All Determinations Except Total Moisture

Time of Sampling.

1. (*a*) The coke shall be sampled while it is being loaded into or unloaded from railroad cars, ships, barges, or trucks, or when discharged from supply bins, railroad cars, grab buckets, or other coke-conveying equipment.

(*b*) Samples collected from the surface of coke in piles, bins, cars, ships or barges are, in general, unreliable because of size segregation and should not be used for determining conformance to specifications unless the purchaser and seller so agree. In case it is necessary to collect a sample of coke from the surface of loaded shipments, nine equal increments shall be taken about 1 ft. below the surface. The nine sampling points shall be located as shown in Fig. 1.

Size of Increments.

2. To collect samples, a shovel or specially designed tool or mechanical means shall be used for taking equal portions or increments. The gross sample shall consist of not less than 25 nor more than 50 increments of approximately equal quantity, except that when samples are collected from the surface of loaded shipments the gross sample shall consist of 9 increments of approximately equal quantity.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. W. A. Selvig, Secretary of Committee D-5 on Coal and Coke, U. S. Bureau of Mines, 4800 Forbes St., Pittsburgh, Pa.

Collection of Gross Sample. 3. The increments shall be regularly and systematically collected, so that the entire quantity of coke sampled will be represented proportionately in the gross sample, and with such frequency that a gross sample of the required amount will be collected. The standard gross sample shall be not less than the quantities given in the following table:

MINIMUM WEIGHTS OF GROSS SAMPLES OF COKE

Run-of-oven, Blast-furnace, Foundry, Water-gas, and any coke containing a range of size of pieces made from uncrushed or coarsely crushed coal (more than 10 per cent on ¼-in. square-hole sieve) except coke breeze	500 lb.[a]
Run-of-oven, Blast-furnace, Foundry, Water-gas and any coke containing a range of size of pieces made from crushed coal (not less than 90 per cent passing through a ¼-in. square-hole sieve) except coke breeze	250 lb.[a]
Closely-sized coke free of coke breeze	125 lb.
Coke breeze (all passing a ½- or ¾-in. square-hole sieve)	125 lb.

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[a] In case the pulverization of the coal is not known, take quantities designated for coke made from uncrushed or coarsely crushed coal.

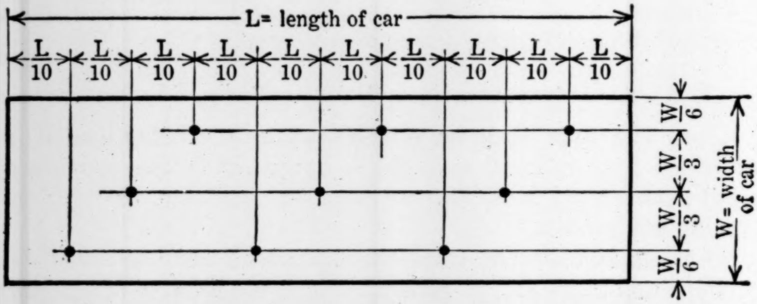

FIG. 1.—Location of Sampling Points from Exposed Surface of Car.

Quantity Represented. 4. A gross sample shall be taken for each 250 tons or fraction thereof, or in case of larger tonnages, for such quantities as may be agreed upon. Each lot of coke arising from a different source or known to be of different quality or size shall be sampled separately.

Crushing. 5. The entire gross sample shall be crushed, mixed, and reduced in quantity to convenient size for transmission to the laboratory. The sample shall be crushed preferably by means of jaw or roll crushers, or in case mechanical crushing means are not available, the coke sample shall be crushed on a chilled-iron or hard-steel plate by impact of a tamper, hard bar or sledge, avoiding all rubbing action, as otherwise the ash content may be materially increased by the addition of iron from the sampling apparatus, even though hardened iron or steel is used. The crushing shall be done under such conditions as shall prevent loss of coke or accidental admixture of foreign matter. Samples of the quantities indicated in Table I shall be crushed so that no pieces of coke and impurities will be greater in dimension, as judged by eye, than specified for the sample before division into two approximately equal parts.

TABLE I.—WEIGHTS OF COKE SAMPLES WITH CORRESPONDING CRUSHING SIZES.

WEIGHT OF SAMPLE TO BE DIVIDED, LB.	LARGEST SIZE OF COKE AND IMPURITIES ALLOWABLE IN SAMPLE BEFORE DIVISION
250 or over	1 in.
125	$\frac{3}{4}$ in.
60	$\frac{1}{2}$ in.
30	$\frac{1}{4}$ in.

The method of reducing by hand the quantity of coke in a gross sample shall be carried out as described in Section 6, even should the initial size of coke and impurities be less than indicated in Table I.

Mixing and Reduction.

6. The progressive reduction in the weight of the sample to the quantities indicated in Table I shall be done by the following methods which are described and illustrated in Plate V of the Standard Method of Sampling Coal (A.S.T.M. Designation: D 21) of the American Society for Testing Materials.[1]

(*a*) The alternate-shovel method of reducing the gross sample shall be repeated until the sample is reduced to approximately 125 lb., and care shall be observed before each reduction in quantity that the sample has been crushed to the fineness specified in Table I.

The crushed coke shall be shoveled into a conical pile (Fig. 2 or 7, Plate V)[1] by depositing each shovelful of coke on top of the preceding one, and then formed into a long pile in the following manner: The sampler shall take a shovelful of coke from the conical pile and spread it out in a straight line (Fig. 3*A* or 8*A*) having a width equal to the width of the shovel and a length of 5 to 10 ft. The next shovelful shall be spread directly over the top of the first shovelful, but in the opposite direction, and so on back and forth, the pile being occasionally flattened, until all the coke has been formed into one long pile (Fig. 3*B* or 8*B*). The sampler shall then discard half of this pile, proceeding as follows:

Beginning on one side of the pile, at either end, and shoveling from the bottom of the pile, the sampler shall take one shovelful (shovelful No. 1, Fig. 4 or 9) and set it aside; advancing along the side of the pile a distance equal to the width of the shovel, he shall take a second shovelful (shovelful No. 2) and discard it; again advancing in the same direction one shovel width, he shall take a third shovelful (shovelful No. 3) and add it to the first. The fourth (shovelful No. 4) shall be taken in a like manner and discarded, the fifth (shovelful No. 5) retained, and so on, the sampler advancing always in the same direction around the pile so that its size will be gradually reduced in a uniform manner. When the pile is removed, about half of the original quantity of coke should be contained in the new pile formed by the alternate shovelsful which have been retained. (Fig. 5*A* or 10*A* show the retained halves, and Fig. 5*B* or 10*B* the rejected halves.)

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[1] 1933 Book of A.S.T.M. Standards, Part II, p. 320.

(*b*) After the gross sample has been reduced by the alternate-shovel method to approximately 125 lb., further reduction in quantity shall be by the quartering method. Before each quartering, the sample shall be crushed to the fineness specified in Table I.

Quantities of 60 to 125 lb. shall be mixed thoroughly by coning and reconing (Figs. 12 and 13); quantities less than 60 lb. shall be placed on a suitable cloth, measuring about 6 by 8 ft., mixed by raising first one end of the cloth and then the other (Fig. 18, 24 or 30), so as to roll the coke back and forth, and after being mixed thoroughly shall be formed into a conical pile by gathering together the four corners of the cloth (Fig. 19, 25 or 31). The quartering of the conical pile shall be done as follows:

The cone shall be flattened, its apex being pressed down and worked outward by means of a shovel, so that after the pile has been quartered, each quarter will contain the material originally in it. The flattened mass, which shall be of uniform thickness and diameter, shall then be marked into quarters (Fig. 14, 20, 26 or 32) by two lines that intersect at right angles directly under a point corresponding to the apex of the original cone. The diagonally opposite quarters (*BB* in Fig. 16, 22, 28 or 34) shall then be shoveled away and discarded and the space that they occupied brushed clean. The coke remaining shall be crushed, mixed, coned, and quartered successively until the sample is reduced to approximately 30 lb.

(*c*) The 30-lb. quantity shall be crushed to $\frac{1}{4}$-in. size, mixed, coned, flattened and quartered. The laboratory samples shall include all of one of the quarters, or all of the two opposite quarters, as may be required. The laboratory sample shall be placed immediately in a suitable container and sealed in such a manner as to preclude tampering.

Reduction by Mechanical Means.

7. Only such riffles or other mechanical means as will give equally representative samples shall be used in substitution for the hand method of reduction in quantity herein standardized.

FOR THE DETERMINATION OF TOTAL MOISTURE

Sample for Total Moisture.

8. For determining total moisture, a special moisture sample weighing approximately 50 lb. shall be taken, except in the case of coke breeze, in which case the moisture sample shall weigh approximately 25 lb. The moisture sample shall be taken when the coke is being loaded or unloaded as the case may be, and shall be accumulated by placing in a waterproof receptacle with a tight-fitting lid small equal parts of the freshly-taken increments of the standard gross sample described in Section 2. The special moisture sample, without any preliminary crushing, shall preferably be dried to constant weight at a temperature of not less than 104 nor more than 200° C.[1] In case it is impracticable to dry the entire sample, the following procedures may be used:

For Coke Appearing Dry.—The special moisture sample shall be crushed rapidly to $\frac{1}{2}$-in size and reduced mechanically or by hand to about a 5-lb. quantity, which shall be immediately placed in a container and sealed air-tight and forwarded to the laboratory without delay.

For Coke Appearing Wet.—The special moisture sample shall be spread on tared pans, weighed, and air-dried or dried in a warm place or on a warm or heated surface until the coke appears dry, and weighed again. The sampling shall be completed as described in the preceding paragraph for coke appearing dry. This loss in weight divided by weight of sample, multiplied by 100, is the percentage of air-drying loss and should be corrected as follows for the moisture found in the sample sent to the laboratory:

$$\begin{array}{c}\text{Percentage}\\ \text{total moisture}\\ \text{(as received)}\end{array} = \frac{100 - \text{percentage of air-drying loss}}{100} \times \begin{array}{c}\text{percentage}\\ \text{moisture in air-}\\ \text{dried sample}\end{array} + \begin{array}{c}\text{percentage}\\ \text{of air-dry-}\\ \text{ing loss.}\end{array}$$

REPORT

Report.

9. Since in the report of the analysis, a brief description should be given of the method of taking the sample, by such characteristic expressions as "Belt Sample," "Top-of-car," etc., information as to how the sample is taken shall be included in the description which accompanies the sample sent to the laboratory.

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[1] Experiments made at the U. S. Bureau of Mines have shown that results checking within 0.5 per cent are obtained between these temperature limits. See A. C. Fieldner and W. A. Selvig, "The Determination of Moisture in Coke," U. S. Bureau of Mines *Technical Paper No. 148* (1917).

TENTATIVE SPECIFICATIONS
FOR
RAW SOYBEAN OIL[1]

A.S.T.M. Designation: D 124 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1922; REVISED, 1933.

Properties

1. Raw soybean oil shall conform to the following requirements:

	MAXIMUM	MINIMUM
Foots, per cent	2.5	...
Loss on heating at 105 to 110 C., per cent	0.1	...
Specific gravity at 15.5/15.5 C	...	0.924
Acid number	3.0	...
Saponification number	...	190
Iodine number (Wijs)	...	131
Color	Not darker than a freshly prepared solution of 1.0 g. potassium dichromate in 100 ml. pure H_2SO_4 (sp. gr. 1.84) or its equivalent in iron-cobalt solution.	

METHODS OF TESTING

Solutions Required

2. The following reagents will be required:

(*a*) *Acetone.*—Acetone shall conform to the Standard Specifications for Acetone (A.S.T.M. Designation: D 329) of the American Society for Testing Materials.[2]

(*b*) *Acid Calcium Chloride Solution.*—Saturate with calcium chloride a mixture of 90 parts of water and 10 parts of HCl (sp. gr. 1.19).

(*c*) *Standard Sodium Thiosulfate Solution.*—Dissolve pure sodium thiosulfate in distilled water that has been well boiled to free it from carbon dioxide in the proportion so that 24.83 g. crystallized sodium thiosulfate will be present in 1000 ml. of the solution. It is best to let this solution stand for about two weeks before standardizing. Standardize with pure resublimed iodine. (See Treadwell-Hall,

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. M. Rea Paul, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

[2] 1933 Book of A.S.T.M. Standards, Part II, p. 703.

Analytical Chemistry, Vol. II, sixth edition, pp. 551 and 553.) This solution will be approximately 0.1 *N* and it is best to leave it as it is after determining its exact iodine value, rather than to attempt to adjust it to exactly 0.1 *N* strength. Preserve in a stock bottle with a guard tube filled with soda lime.

(*d*) *Starch Solution.*—Stir up 2 to 3 g. of potato starch or 5 g. of soluble starch with 100 ml. of 1 per cent salicylic acid solution, add 300 to 400 ml. boiling water, and boil the mixture until the starch is practically dissolved. Dilute to 1 liter.

(*e*) *Potassium Iodide Solution (15 per cent).*—Dissolve 150 g. of potassium iodide free from iodate in distilled water and dilute to 1000 ml.

(*f*) *Wijs Iodine Monochloride Solution.*—Dissolve iodine in glacial acetic acid that has a melting point of 14.7 to 15 C. and which is free from reducing impurities in the proportion so that 13 g. of iodine will be present in 1000 ml. of solution. The preparation of the iodine monochloride solution presents no great difficulty, but it shall be done with care and accuracy in order to obtain satisfactory results. There shall be in the solution no sensible excess either of iodine or more particularly of chlorine over that required to form the monochloride. This condition is most satisfactorily attained by dissolving in the whole of the acetic acid to be used the requisite quantity of iodine, using a gentle heat to assist the solution, if it is found necessary. The halogen content can be accurately measured by titration of a portion of the solution with 0.1 *N* sodium thiosulfate using the potassium iodide solution (15 per cent) and the starch indicator as described in Section 3 (*g*) in the method for the determination of the iodine number. Set aside a small portion of this solution while pure, and pass dry chlorine into the remainder until the halogen content of the solution is doubled. Ordinarily, it will be found that by passing the chlorine into the main part of the solution until the characteristic color of free iodine has just been discharged, there will be a slight excess of chlorine, which is corrected by the addition of the requisite amount of the unchlorinated portion until all free chlorine has been destroyed. A slight excess of iodine does little or no harm, but excess of chlorine must be avoided.

(*g*) *Standard Sodium Hydroxide Solution.*—Prepare a stock concentrated solution of sodium hydroxide by dissolving NaOH in water in the proportion of 200 g. NaOH to 200 ml. water. Allow this solution to cool and settle in a stoppered bottle for several days. Decant the clear liquid from the precipitate of sodium carbonate into another clean bottle. Add clear barium hydroxide solution until no further precipitate forms. Again allow to settle until clear. Draw off about 175 ml. and dilute to 10 liters with freshly boiled distilled water. Preserve in a stock bottle provided with a large guard tube filled with soda lime. Determine the exact strength by titrating against pure benzoic acid (C_6H_5COOH) using phenolphthalein as indicator. (See Bureau of Standards *Scientific Paper No. 183.*) This solution will be approximately 0.25 *N*, but do not attempt to adjust it to any exact value. Determine its exact strength and make proper corrections in using it.

(*h*) *Alcoholic Sodium Hydroxide Solution.*—Dissolve pure NaOH in 95 per cent ethyl alcohol in the proportion of about 22 g. per 1000 ml. Let stand in a stoppered bottle. Decant the clear liquid into another bottle and keep well stoppered. This solution should be colorless or only slightly yellow when used; it will keep colorless longer if the alcohol is previously treated with NaOH (about 80 g. to 1000 ml.), kept at about 50 C. for 15 days, and then distilled. For an alternate method see *Journal*, American Chemical Society, 1906, p. 395.

(*i*) *Half Normal Sulfuric Acid Solution.*—Add about 15 ml. of H_2SO_4 (sp. gr. 1.84) to distilled water, cool and dilute to 1000 ml. Determine the exact strength by titrating against freshly standardized NaOH or by any other accurate method. Either adjust to exactly 0.5 *N* strength or leave as originally made, applying appropriate correction.

Methods of Testing

3. The oil shall be tested in accordance with the following methods:

(*a*) *General.*—The laboratory sample shall be thoroughly mixed by shaking, stirring, or pouring from one vessel to another and the samples for the individual tests taken from this thoroughly mixed sample.

(*b*) *Foots.*—With all materials at a temperature between 20 and 27 C., mix by shaking for exactly one minute in a graduated tube, 25 ml. of the well-shaken sample of oil, 25 ml. of acetone and 10 ml. of the acid calcium chloride solution. Clamp the tube in a vertical position where settling may take place for 24 hr. The temperature during this period should be between 20 and 27 C.

At the end of the 24 hr., determine the volume of the stratum lying between the clear calcium chloride solution and the clear acetone and oil mixture to the nearest 0.1 ml. or fraction thereof. This volume multiplied by four expresses the amount of foots present as a percentage by volume.

The graduated tube referred to may be a burette or a color comparison tube. It should have an internal diameter of from 1.0 to

1.5 cm., and a capacity of not less than 70 ml. The graduations in 0.1 ml. should extend at least from 10 ml. to 50 ml. above the bottom of the tube.

(*c*) *Loss on Heating at 105 to 110 C.*—Place 10 g. of the oil in an accurately weighed 200-ml. Erlenmeyer flask; weigh. Heat in an oven at a temperature between 105 and 110 C. for 30 minutes; cool and weigh. Calculate the percentage loss. This determination shall be made in a current of dry carbon dioxide gas.

(*d*) *Specific Gravity.*—Use a pycnometer accurately standardized and having a capacity of at least 25 ml., or any other equally accurate method, making the test at 15.5 C., water being 1 at 15.5 C.

(*e*) *Acid Number.*—Weigh from 5 to 10 g. of the oil. Transfer to a 300-ml. Erlenmeyer flask. Add 50 ml. of neutral 95 per cent ethyl alcohol. Put a condenser loop inside the neck of the flask. Heat on a steam bath for 30 minutes. Cool and add phenolphthalein indicator. Titrate to a faint permanent pink color with the 0.2 N sodium hydroxide solution. Calculate the acid number (milligrams KOH per gram of oil).

(*f*) *Saponification Number.*—Weigh about 2 g. of the oil in a 300-ml. Erlenmeyer flask. Add 25 ml. of alcoholic sodium hydroxide solution. Put a condenser loop inside the neck of the flask and heat on the steam bath for 1 hr. Cool, add phenolphthalein as indicator, and titrate with 0.5 N H_2SO_4. Run two blanks with the alcoholic sodium hydroxide solution. These should check within 0.1 ml. of 0.5 N H_2SO_4. From the difference between the number of milliliters of 0.5 N H_2SO_4 required for the blank and for the determination, calculate the saponification number (milligrams KOH required for 1 g. of the oil).

(*g*) *Iodine Number (Wijs).*—Place a small quantity of the sample in a small weighing burette or beaker. Weigh accurately. Transfer by dropping from 0.09 to 0.15 g. of oil to a 500-ml. bottle, having a well-ground glass stopper, or an Erlenmeyer flask, having a specially flanged neck for the iodine tests. Reweigh the burette or beaker and determine the amount of sample used. Add 10 ml. of chloroform. Whirl the bottle to dissolve the sample. Add 10 ml. of chloroform to each of two empty bottles like that used for the sample. Add to each bottle 25 ml. of the Wijs solution and let stand with occasional shaking for 1 hr. in a dark place at a temperature of from 21 to 23 C. Add 10 ml. of the potassium iodide solution (15 per cent) and 100 ml. of water. Titrate with 0.1 N sodium thiosulfate, using starch as an indicator. The titrations on the two blank tests should agree within 0.1 ml. From the difference between the average of the blank titrations and the titration on the samples and the iodine value of the thiosulfate solution calculate the iodine number of the samples tested. (Iodine number is given in centigrams of iodine to 1 g. of sample.)

(*h*) *Color.*—Prepare a fresh solution of pure potassium dichromate in pure colorless H_2SO_4 (sp. gr. 1.84). This solution should be in the proportion of 1.0 g. potassium dichromate to 100 ml. (184.0 g.) H_2SO_4. Place the oil and colored solution in separate thin-walled, clear glass tubes of the same diameter (1 to 2 cm.) to a depth of not less than 2.5 cm. and compare the depths of color by looking transversely through the columns of liquid by transmitted light.

The iron-cobalt liquid equivalent to 1 g. of the dichromate solution may be prepared as follows: Mix 29.4 ml. of Solution No. 1 with 17.6 ml. of Solution No. 2 and 53.0 ml. of Solution No. 3. The three base solutions referred to have the following composition:

Solution No. 1..........	5.0 g. of $FeCl_3\cdot 6H_2O$ 1.2 g. of 2-per-cent HCl
Solution No. 2..........	1.0 g. of $CoCl_2\cdot 6H_2O$ 3.0 g. of 2-per-cent HCl
Solution No. 3..........	For each gram of I_2 there are 27.2 g. of $NiSO_4\cdot 7H_2O$, and 12 g. of KI

TENTATIVE SPECIFICATIONS
FOR
SPIRITS OF TURPENTINE[1]

A.S.T.M. Designation: D 13 - 33 T

This is a **Tentative Standard,** issued for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ADOPTED, 1915; REVISED, 1924, 1926; REISSUED AS TENTATIVE, 1933.

Scope

1. These specifications apply to the following kinds of spirits of turpentine:

Gum spirits of turpentine;
Steam-distilled wood turpentine;
Sulfate wood turpentine; and
Destructively-distilled wood turpentine.

The purchaser should specify the kind of spirits of turpentine desired.

Properties and Tests

2. Spirits of turpentine shall be pure and shall conform to the following requirements:

	Gum Spirits of Turpentine		Wood Turpentine					
			Steam Distilled		Sulfate		Destructively Distilled	
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
Specific gravity, 15.5/15.5 C.	0.875	0.860	0.875	0.860	0.875	0.860	0.866	0.860
Refractive index at 20 C., *D* line	1.478	1.465	1.478	1.465	1.478	1.465	1.483	1.463
Residue after polymerization with 38*N* H_2SO_4:								
Volume, per cent	2	....	2	....	2	....	2	....
Refractive index at 20 C.	....	1.500	....	1.500	....	1.500	....	1.480
Initial boiling point at 760-mm. pressure, deg. Cent.	160	150	160	150	160	150	157	150
Distilling below 170 C. at 760-mm. pressure, per cent	....	90	....	90	....	90	....	60
Distilling below 180 C. at 760-mm. pressure, per cent	....	....	....	....	....	....	....	90

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. M. Rea Paul, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

These specifications are in effect a revision of and replace the former Standard Specifications for Gum Spirits of Turpentine and Steam-Distilled Wood Turpentine (A.S.T.M. Designation: D 13 - 26) and Standard Specifications for Destructively Distilled Wood Turpentine (A.S.T.M. Designation: D 236 - 27) which standards were accordingly discontinued in 1933.

Appearance

3. Spirits of turpentine shall be clear and free from suspended matter and water.

Color

4. The color shall be "standard" or better.

Odor

5. The odor shall be mild and characteristic of the kind of spirits of turpentine specified. If desired, deliveries shall conform to the odor of the sample mutually agreed upon by the purchaser and seller.

Methods of Testing

6. The sampling and methods of testing shall be conducted in accordance with the Standard Methods of Sampling and Testing Turpentine (A.S.T.M. Designation: D 233) of the American Society for Testing Materials.[1]

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[1] 1933 Book of A.S.T.M. Standards, Part II, p. 668.

TENTATIVE SPECIFICATIONS
FOR
SHELLAC VARNISH[1]

A.S.T.M. Designation: D 359 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1933.

Scope

1. Shellac varnish is a solution or "cut" of a specified grade of pure orange or dry bleached shellac (the manufactured product from the secretion of the *Tachardia lacca*, with no other added resin, copal, or other adulterants) in the most commonly used solvent, 95 per cent (190-proof) specially denatured alcohol, Formula No. 1 of the U. S. Internal Revenue Bureau, or in other specified denatured alcohol or solvent.

NOTE.—For shellac varnishes from which a large percentage of the insoluble matter has been removed by modern machinery, see the Tentative Specifications for Centrifuged Shellac Varnish (A.S.T.M. Designation: D 360 - 33 T) of the American Society for Testing Materials.[2]

Types

2. Shellac varnish shall be furnished as Orange, Grades A, B, C or D, and as Bleached, Grades "Regular" or "Refined." Each type shall be furnished as light, medium, heavy, or very heavy, as specified, or of any other body mutually agreed upon by the purchaser and seller.

Color

3. The color of shellac varnish shall be equal to the color of a standard varnish of similar concentration mutually agreed upon by the purchaser and seller.

NOTE.—Attention is called to the fact that the purchaser and seller must agree upon one of the two methods for determining color appearing in the Standard Methods of Sampling and Testing Shellac (A.S.T.M. Designation: D 29) of the American Society for Testing Materials.[3]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. M. Rea Paul, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

[2] See p. 729.

[3] 1933 Book of A.S.T.M. Standards, Part II, p. 693.

Copal

4. All pure shellac varnishes shall not contain gum copal.

Drying Time

5. Shellac varnish shall dry hard in 1 hour. Shellac varnishes having a body greater than that for a light body varnish shall be thinned to the concentration of the light varnish. Special conditions for this test may be made by mutual agreement between the purchaser and seller.

Body

6. The body of the respective types shall be based upon the percentage of non-volatile matter, and shall conform to the following minimum requirements:

	NON-VOLATILE MATTER, MINIMUM, PER CENT	
	ORANGE GRADES A, B, C, OR D	BLEACHED REGULAR OR REFINED
Light body varnish	35.5	34.5
Medium body varnish	38.5	37.0
Heavy body varnish	40.5	39.5
Very heavy body varnish	45.0	43.5

Properties

7. The non-volatile matter in the varnish shall conform to the following requirements:

	ORANGE				BLEACHED	
	GRADE A	GRADE B	GRADE C	GRADE D	REGULAR	REFINED
Iodine number, maximum	18.0	18.0	18.0	24.5	10.0	10.0
Matter insoluble in specified hot solvents, maximum, per cent	1.75	2.50	3.00	3.00	1.0	0.2
Wax, maximum, per cent	5.5	5.5	5.5	5.5	5.5	0.2
Ash, maximum, per cent	1.0	1.0	1.0	1.0	1.0	0.3

Packing and Marking

8. Shellac varnish shall be delivered in standard commercial containers. Each container shall be marked "pure."

Methods of Testing

9. The sampling and methods of testing shall be conducted in accordance with the Standard Methods of Sampling and Testing Shellac (A.S.T.M. Designation: D 29) of the American Society for Testing Materials.[1]

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[1] 1933 Book of A.S.T.M. Standards, Part II, p. 678.

TENTATIVE SPECIFICATIONS
FOR
CENTRIFUGED SHELLAC VARNISH[1]

A.S.T.M. Designation: D 360 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1933.

Scope

1. Centrifuged shellac varnish is a solution or "cut" of a specified grade of pure orange or dry bleached shellac (the manufactured product from the secretion of the *Tachardia lacca*, with no other added resin, copal, or other adulterants) in the most commonly used solvent, 95 per cent (190-proof) specially denatured alcohol, Formula No. 1 of the U. S. Internal Revenue Bureau, or in other specified denatured alcohol or solvent, which has been subjected to centrifugal force or other cleaning mechanism where most of the insoluble material has been removed.

Types

2. Centrifuged shellac varnish shall be furnished as Orange, Grades A or B and as Bleached, Grades, "Regular" or "Refined." Each type shall be furnished as light, medium, heavy, or very heavy, as specified, or of any other body mutually agreed upon by the purchaser and seller.

Color

3. The color of shellac varnish shall be equal to the color of a standard varnish of similar concentration mutually agreed upon by the purchaser and seller.

NOTE.—Attention is called to the fact that the purchaser and seller must agree upon one of the two methods for determining color appearing in the Standard Methods of Sampling and Testing Shellac (A.S.T.M. Designation: D 29) of the American Society for Testing Materials.[2]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. M. Rea Paul, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

[2] 1933 Book of A.S.T.M. Standards, Part II, p. 693.

Copal

4. All pure shellac varnishes shall not contain gum copal.

Drying Time

5. Shellac varnish shall dry hard in 1 hour. Shellac varnishes having a body greater than that for a light body varnish shall be thinned to the concentration of the light varnish. Special conditions for this test may be made by mutual agreement between the purchaser and seller.

Body

6. The body of the respective types shall be based upon the percentage of non-volatile matter, and shall conform to the following minimum requirements:

	NON-VOLATILE MATTER, MINIMUM, PER CENT	
	ORANGE GRADES A OR B	BLEACHED REGULAR OR REFINED
Light body varnish	35.0	34.5
Medium body varnish	38.0	37.0
Heavy body varnish	40.0	39.5
Very heavy body varnish	44.5	43.5

Properties

7. The non-volatile matter in the varnish shall conform to the following requirements:

	ORANGE		BLEACHED	
	GRADE A	GRADE B	REGULAR	REFINED
Iodine number, maximum	18.0	24.5	10.0	10.0
Matter insoluble in specified hot solvents, maximum, per cent	1.0	1.0	1.0	0.2
Wax, maximum, per cent	5.5	5.5	5.5	0.2
Ash, maximum, per cent	1.0	1.0	1.0	0.3

Packing and Marking

8. Shellac varnish shall be delivered in standard commercial containers. Each container shall be marked "pure."

Methods of Testing

9. The sampling and methods of testing shall be conducted in accordance with the Standard Methods of Sampling and Testing Shellac (A.S.T.M. Designation: D 29) of the American Society for Testing Materials.[1]

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[1] 1933 Book of A.S.T.M. Standards, Part II, p. 678.

TENTATIVE SPECIFICATIONS

FOR

INDUSTRIAL 90 PER CENT BENZENE (BENZOL)[1]

A.S.T.M. Designation: D 361 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1933.

Properties

1. Industrial 90 per cent benzene (benzol) shall conform to the following requirements:

Specific gravity, 20/20 C.	0.868 to 0.882
Color	water white
Distillation range:[a]	
Below 77 C.	none
Below 100 C.	not less than 92 per cent
Above 122 C.	none
Non-volatile matter	not more than 0.005 g. per 100 ml.
Odor	characteristic aromatic hydrocarbon, non-residual
Water	not sufficient to show turbidity
Acidity	none
Sulfur as H_2S and SO_2	none
Corrosion:	
Copper corrosion test	copper shall show no iridescence
Mercury test	mercury shall show no discoloration

[a] The thermometer used for the distillation test shall conform to the requirements of the Standard Specifications for A.S.T.M. Partial-Immersion Thermometer for General Use, −20 to +150 C., 0 to +300 F. (A.S.T.M. Designation: D 182) of the American Society for Testing Materials.[2]

Methods of Testing

2. (*a*) The sampling and methods of testing shall be conducted in accordance with the Standard Methods of Sampling and Testing Lacquer Solvents and Diluents (A.S.T.M. Designation: D 268) of the American Society for Testing Materials.[3]

(*b*) *Corrosion* (*Mercury Test*).—A 10-ml. sample of the solvent shall be shaken with 1 ml. of clean mercury in a stoppered test tube, and allowed to stand 15 minutes. The mercury shall show no discoloration when compared with a blank run with distilled water.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. M. Rea Paul, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

[2] 1933 Book of A.S.T.M. Standards, Part II, p. 1236.

[3] *Ibid.*, p. 722.

TENTATIVE SPECIFICATIONS

FOR

INDUSTRIAL PURE TOLUENE (TOLUOL)[1]

A.S.T.M. Designation: D 362 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1933.

Properties

1. Industrial pure toluene (toluol) shall conform to the following requirements:

Specific gravity, 20/20 C	0.860 to 0.870
Color	water white
Distillation range:[a]	
Below 107.5 C	none
Above 112.5 C	none
The total distillation range of any specific sample shall not be greater than 3.0 C.	
Non-volatile matter	not more than 0.005 g. per 100 ml.
Odor	characteristic aromatic hydrocarbon, non-residual
Water	not sufficient to show turbidity
Acidity	none
Sulfur as H_2S and SO_2	none
Corrosion:	
Copper corrosion test	copper shall show no iridescence
Mercury test	mercury shall show no discoloration

[a] The thermometer used for the distillation test shall conform to the requirements of the Standard Specifications for A.S.T.M. Partial-Immersion Thermometer for General Use, −20 to +150 C., 0 to +300 F. (A.S.T.M. Designation: D 182) of the American Society for Testing Materials.[2]

Methods of Testing

2. (*a*) The sampling and methods of testing shall be conducted in accordance with the Standard Methods of Sampling and Testing Lacquer Solvents and Diluents (A.S.T.M. Designation: D 268) of the American Society for Testing Materials.[3]

(*b*) *Corrosion* (*Mercury Test*).—A 10-ml. sample of the solvent shall be shaken with 1 ml. of clean mercury in a stoppered test tube, and allowed to stand 15 minutes. The mercury shall show no discoloration when compared with a blank run with distilled water.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. M. Rea Paul, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

[2] 1933 Book of A.S.T.M. Standards, Part II, p. 1236.

[3] *Ibid.*, p. 722.

TENTATIVE SPECIFICATIONS AND TESTS
FOR
TRICRESYL PHOSPHATE[1,2]

A.S.T.M. Designation: D 363 – 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1933.

Properties

1. Tricresyl phosphate shall conform to the following requirements:

Specific gravity, 20/20 C	1.160 to 1.180
Color	not more than 100 on the Hazen platinum cobalt standard
Volatile matter	not more than 0.20 per cent
Free phenols	not more than 0.05 per cent
Potassium permanganate test	no change in color after standing 30 minutes
Ester value[a]	not less than 99 per cent
Odor	substantially none
Water	miscible without turbidity with 19 volumes of 60° Baumé gasoline at 20 C.
Acid (free acid)	not more than 0.1 mg. KOH per gram of sample

[a] Ester value shall be determined in accordance with Section 11 of Standard Methods D 268,[3] except that the heating period shall be from 8 to 16 hr.

Methods of Testing

2. The sampling and methods of testing shall be conducted in accordance with the Standard Methods of Sampling and Testing Lacquer Solvents and Diluents (A.S.T.M. Designation: D 268) of

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. M. Rea Paul, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

By adoption of these specifications, the American Society for Testing Materials does not undertake to insure anyone utilizing such specifications against liability for infringement of any patent or assume any such liability, and such adoption does not constitute a recommendation of any patented or proprietary application that may be involved.

[2] Prepared from commercial cresylic acid.

[3] 1933 Book of A.S.T.M. Standards, Part II, p. 722.

the American Society for Testing Materials,[1] supplemented by the methods of test described in Sections 3 to 8 of these specifications:

Color

3. Color shall be determined in accordance with Section 4 of the Standard Methods of Sampling and Testing Lacquer Solvents and Diluents (A.S.T.M. Designation: D 268).[1] The Hazen platinum cobalt solution prepared as follows,[2] shall be used as the standard for the color test:

Dissolve 1.246 g. of potassium platinic chloride ($PtCl_4 \cdot 2KCl$) containing 0.05 g. of platinum and 1 g. of crystallized cobalt chloride ($CoCl_2 \cdot 6H_2O$) containing 0.25 g. of cobalt in 100 ml. of concentrated HCl and make up to 1 l. with distilled water. This solution has a standard color of 500.

By placing 4 ml. of the color solution in a colorless 100-ml. Nessler tube and diluting to the mark with distilled water, a standard color of 20 is obtained. For a standard color of 100, 20 ml. of the color solution shall be used.

Volatile Matter

4. A 100-g. sample of the tricresyl phosphate shall be placed in a weighed porcelain evaporating dish and heated at a temperature of from 100 to 105 C. in an oven for 16 hr. The loss in the weight of the dish and contents is the volatile matter of the sample and shall be expressed as a percentage of the original sample.

Free Phenols in Tricresyl Phosphate

5. *Reagents.*—The following reagents will be required:

Sodium Hydroxide Solution (2.5 per cent).

Sodium Bromide-Bromate Solution containing 10.09 g. of sodium bromide and 2.95 g. of sodium bromate per liter.

Potassium Iodide Solution (6 per cent).

Hydrochloric Acid, Concentrated (sp. gr. 1.19).

Starch Solution (1 per cent).

0.0394 *N Sodium Thiosulfate Solution* ($Na_2S_2O_3 \cdot 5H_2O$).

Procedure

6. (*a*) *Preparation of Sample.*—A 10-g. sample of the tricresyl phosphate shall be weighed and transferred to a 250-ml. volumetric flask; 50 ml. of the sodium hydroxide solution (2.5 per cent) at 65 C.

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[1] 1933 Book of A.S.T.M. Standards, Part II, p. 722.

[2] This method is described in "Standard Methods of Chemical Analyses," Vol. 2, Third edition, Scott.

shall then be added and the flask shaken vigorously for 3 minutes. This solution shall then be diluted to the 250-ml. mark and filtered. A 100-ml. portion of the filtrate shall then be pipetted into a 300-ml. flask for titration.

(*b*) *Titration of Sample.*—After the aliquot sample has been pipetted into the 300-ml. flask, 15 ml. of the sodium bromide-bromate solution shall be added from a burette, and then 5 ml. of HCl. The HCl shall be added quickly and the rubber stopper put in place immediately. The flask shall be shaken and allowed to stand for 15 minutes. Ten milliliters of the potassium iodide solution shall then be added and the solution titrated with the 0.0394 N sodium thiosulfate solution ($Na_2S_2O_3 \cdot 5H_2O$), using the starch solution as an indicator. The starch solution shall be added near the end of the titration. The fading out of the blue color marks the end point of the titration.

The reactions are as follows:

$$5NaBr + NaBrO_3 + 6HCl = 6NaCl + 3H_2O + 3Br_2$$
$$CH_3C_6H_4OH + 3Br_2 = CH_3C_6HBr_3OH + 3HBr$$

A blank titration shall be run as above, using the same reagents.

Calculation

7. The percentage of free phenols (cresol) shall be calculated from the following formula:

$$\text{Free phenols (Cresol), per cent} = \frac{\begin{array}{r}\text{milliliters } Na_2S_2O_3 \text{ for blank} - \text{milliliters } Na_2S_2O_3 \\ \text{for sample} \times 0.00071 \times 100 \times 2.5\end{array}}{\text{Weight of sample (10 g.)}}$$

Potassium Permanganate Test for Tricresyl Phosphate

8. A 10-g. sample shall be shaken vigorously for 2 minutes with 50 ml. of a 0.01 N freshly prepared potassium permanganate solution in distilled water and let stand for 30 minutes.

TENTATIVE SPECIFICATIONS
FOR
INDUSTRIAL XYLENE (XYLOL) OR SOLVENT NAPHTHA[1]

A.S.T.M. Designation: D 364 – 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1933.

Properties

1. Industrial xylene (xylol) or solvent naphtha shall conform to the following requirements:

Specific gravity, 20/20 C	0.856 to 0.867
Color	water white
Distillation range:[a]	
Below 123 C	none
Below 129 C	not more than 5 per cent
Below 143 C	not less than 90 per cent
Above 160 C	none
Non-volatile matter	not more than 0.005 g. per 100 ml.
Odor	characteristic aromatic hydrocarbon, non-residual
Water	not sufficient to show turbidity
Acidity	none
Sulfur as H_2S and SO_2	none
Corrosion:	
Copper corrosion test	copper shall show no iridescence
Mercury test	mercury shall show no discoloration

[a] The thermometer used for the distillation test shall conform to the requirements of the Standard Specifications for A.S.T.M. Partial-Immersion Thermometer for General Use, −5 to +300 C., +20 to +580 F. (A.S.T.M. Designation: D 183) of the American Society for Testing Materials.[2]

Methods of Testing

2. (*a*) The sampling and methods of testing shall be conducted in accordance with the Standard Methods of Sampling and Testing Lacquer Solvents and Diluents (A.S.T.M. Designation: D 268) of the American Society for Testing Materials.[3]

(*b*) *Corrosion* (*Mercury Test*).—A 10-ml. sample of the solvent shall be taken with 1 ml. of clean mercury in a stoppered test tube, and allowed to stand 15 minutes. The mercury shall show no discoloration when compared with a blank run with distilled water.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. M. Rea Paul, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

[2] 1933 Book of A.S.T.M. Standards, Part II, p. 1238.

[3] *Ibid.*, p. 722.

TENTATIVE METHODS OF TEST

FOR

SOLUBLE NITROCELLULOSE BASE SOLUTIONS[1]

A.S.T.M. Designation: D 365 – 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1933.

Scope

1. These methods are intended for the testing of soluble nitrocellulose base solutions which are made by dispersing various kinds and concentrations of soluble nitrocellulose in various solvent mixtures.

2. Since the desired specifications and compositions of soluble nitrocellulose base solutions vary greatly, the limits desired for each particular type shall be mutually agreed upon by the buyer and vendor.

Sampling

3. Samples shall be taken from not less than 10 per cent of each lot in the shipment. These samples shall then be composited to represent each lot or batch.

CONSISTENCY (VISCOSITY)

Apparatus

4. The falling-ball consistency test apparatus and procedure described in Sections 11 to 13 of the Standard Specifications and Tests for Soluble Nitrocellulose (A.S.T.M. Designation: D 301) of the American Society for Testing Materials[2] shall be used to determine the consistency of those solutions having a consistency of from 3 to 500 seconds when tested in that apparatus.

5. The consistency test described in Sections 10 and 11 of the Tentative Methods of Testing Nitrocellulose Clear Lacquers and Lacquer Enamels (A.S.T.M. Designation: D 333 – 33 T) of the American Society for Testing Materials[3] shall be used to determine

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. M. Rea Paul, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

[2] 1933 Book of A.S.T.M. Standards, Part II, p. 711.

[3] See p. 741.

the consistency of those solutions having a consistency of less than 3 seconds when tested in the falling-ball apparatus referred to in Section 4.

6. The apparatus and method described in Sections 7 and 8 shall be used to determine the consistency of those solutions having a consistency greater than 500 seconds when tested in the falling-ball apparatus referred to in Section 4.

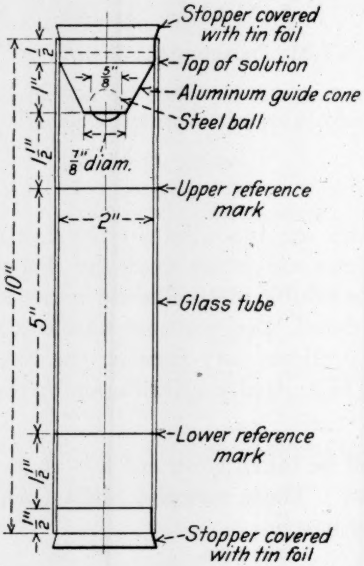
Stopper covered with tin foil
Top of solution
Aluminum guide cone
Steel ball
5/8"
7/8" diam.
Upper reference mark
2"
Glass tube
Lower reference mark
Stopper covered with tin foil
10"
1/2"
1"
1 1/2"
5"
1 1/2"
1/2"

FIG. 1.—Consistency (Viscosity) Test Apparatus.

Apparatus

7. The consistency test apparatus, shown in Fig. 1, shall consist of the following:

(*a*) *Glass Tube.*—A glass tube (preferably resistant glass),[1] 2 in. ± $\frac{1}{32}$ in. (50.8 mm. ± 1.0 mm.) in inside diameter and 10 in. in length, with marks 5 in. ± $\frac{1}{16}$ in. (177 mm. ± 1 mm.) apart, the upper one being 3 in. from the top of the tube.

(*b*) *Steel Ball.*—A $\frac{5}{8}$-in. steel ball, 0.625 in. ± 0.001 in. (15.88 mm. ± 0.02 mm.) in diameter and weighing 16.536 g. ± 0.10 g.

(*c*) *Aluminum Guide Cone.*—A guide cone of light gage aluminum (approximately 0.02 in. in thickness) as shown in Fig. 1. The orifice of the guide cone shall be $\frac{7}{8}$ in. in diameter, the conical portion 1 in. in height, the cylindrical portion $\frac{1}{2}$ in. in height, and the outside diameter shall be slightly under 2 in. so as to fit snugly into the viscosity tube.

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[1] Pyrex glass is very satisfactory for this purpose.

(*d*) *Stoppers.*—Stoppers made preferably of rubber and covered with tin foil.

Procedure

8. The consistency shall be determined as follows:

(*a*) Fill the tube in any convenient manner whereby bubbles do not form or an appreciable amount of solvent is not lost. Among other methods this can be done by immersing the lower end of the open tube in the solution and applying suction at the upper end of the tube. In this manner the tube can be filled in from 5 to 10 seconds without the introduction of air bubbles or an appreciable loss of solvent. Close the bottom of the tube with a stopper covered with tin foil. Push the aluminum guide cone slowly into the top of the tube and insert a stopper covered with tin foil into the top of the guide.

(*b*) Bring the tube and its contents to a temperature of 25 C. ± 0.1 C. by placing in a suitable bath. Allow at least 30 minutes for the solution to reach temperature equilibrium. For accurate measurements keep the tube during the determination either in a thermostat or suspended within a considerably larger cylinder of water at the specified temperature.

(*c*) Remove the upper stopper only long enough to place the ball in the center of the tube; this can be done conveniently with crucible tongs. The principal value of the guide cone is to retard the ball sufficiently at the start of its fall so that the solution will close over the ball and not leave on the top of the ball a large "trailer bubble." If the guide is not used a big trailer bubble usually accompanies the ball, retarding its fall and, if the bubble is off center on the ball, pulling the latter away from the center of the tube.

(*d*) Measure the time of fall in seconds from the instant the bottom of the ball is level with the upper reference mark on the tube until it reaches the lower mark on the tube.

NOTE.—The steel ball can be removed (in order to leave the same material in the tube for a check run) by removing the lower stopper. However, a small air bubble is usually introduced in this way. It is preferable to invert the tube, removing the guide to get the ball out. It is often necessary to put a few drops of solvent in the guide lip to loosen it from the tube on account of the solution drying at the edge of the tube. When the latter method is used for removing the ball, a larger bubble traverses the tube, than when the former method is used, but a large bubble moves sufficiently fast, even in a very viscous solution, to escape at the top in a few minutes, whereas small bubbles take hours to escape.

NON-VOLATILE MATTER

Non-Volatile Matter

9. The percentage of non-volatile matter shall be determined in accordance with the method described in Section 9 of the Tentative Methods of Testing Nitrocellulose Clear Lacquers and Lacquer Enamels (D 333 – 33 T) of the American Society for Testing Materials.[1]

APPEARANCE OF SOLUTION

Appearance

10. The appearance of the soluble nitrocellulose base solution shall be compared with a standard mutually agreed upon by the buyer and vendor (both standard and sample solutions shall be thoroughly agitated before making observations) in similar bottles for turbidity, hair, grain, and insoluble matter.

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[1] See p. 741.

TENTATIVE METHODS OF TESTING NITROCELLULOSE CLEAR LACQUERS AND LACQUER ENAMELS[1]

A.S.T.M. Designation: D 333 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

Issued, 1931; Revised, 1932, 1933

Weight per Gallon.

1. (*a*) The weight in pounds per U. S. gallon shall be obtained by multiplying the specific gravity by 8.32. The specific gravity shall be determined by any convenient method that is accurate to the second decimal place, the temperature of both sample and water being 20 C.

(*b*) *Mobile Liquids.*—For sufficiently mobile liquids a convenient apparatus is an accurately calibrated volumetric flask. Fill to the mark at 20 C. and weigh accurately. Apply the following equation:

$$\text{Sp. gr.} = \frac{\text{Weight in grams of contents}}{\text{Capacity in milliliters}}$$

(*c*) *Viscous Materials.*—For very viscous materials which cannot be conveniently introduced into a volumetric flask, any convenient vessel of known capacity may be used. A suitable apparatus is described in the Standard Method of Test for Specific Gravity of Road Oils, Road Tars, Asphalt Cements and Soft Tar Pitches (A.S.T.M. Designation: D 70) of the American Society for Testing Materials.[2]

Drying Time.

2. The sample and a mutually agreed upon standard shall be flowed without thinning, crosswise on a clean 4 by 8-in. glass plate and examined for drying and hardening at specified periods such as 3 minutes, 15 minutes, 1 hour, and 24 hours. The drying shall be judged by touching or pressing the films with the finger at approximately the same points.

Color.

3. A panel for the color test shall be prepared by pouring the sample and a mutually agreed upon standard on an opaque surface in such a manner that the two materials shall flow together along

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. M. Rea Paul, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

[2] 1933 Book of A.S.T.M. Standards, Part II, p. 1002.

adjacent edges. The background shall be a mutually agreed upon material. A preliminary examination may be made after 1 hour, but the final examination shall not be made until 24 hours after pouring.

Gloss.

4. The panel prepared for the color test in accordance with Section 3 shall be examined after 24 hours for gloss. A convenient method of determining apparent gloss is to hold the test panel at an angle of incidence approaching 180 deg. to a source of artificial light and to note the comparative sharpness of the definition of the image (for example, the lamp filament).

Homogeneity.

5. The sample shall be thinned with the thinner recommended, in the proportions recommended. The thinned sample shall be flowed on a glass panel and dried in a dust-free atmosphere. The panel shall be examined by reflected and transmitted light for pigment dispersion and freedom from particles of foreign matter.

Print Test.

6. The test panel for the print test shall be prepared in a manner mutually agreed upon by the buyer and seller. The test panel shall be covered with two pieces of ordinary cheesecloth over which shall be placed a piece of felt about $\frac{3}{32}$ in. in thickness. A known uniform pressure shall then be applied to the felt, over a circular area of at least 1 in. in diameter for a given length of time. The time allowed for the lacquer to dry before applying the pressure shall be also predetermined.

Tests shall be made under definite, predetermined conditions of temperature and humidity, or, if this is not possible, a standard shall be run at the same time.

Bending Test.

7. The composition of the metal test panel for the bending test, the gage thereof and the manner of application of lacquer coating applied thereto, shall be mutually agreed upon by the buyer and seller.

The test shall be made by bending the panel at a uniform rate through an angle of more than 140 deg. over a mandrel of mutually agreed upon radius.

Outdoor Exposure.

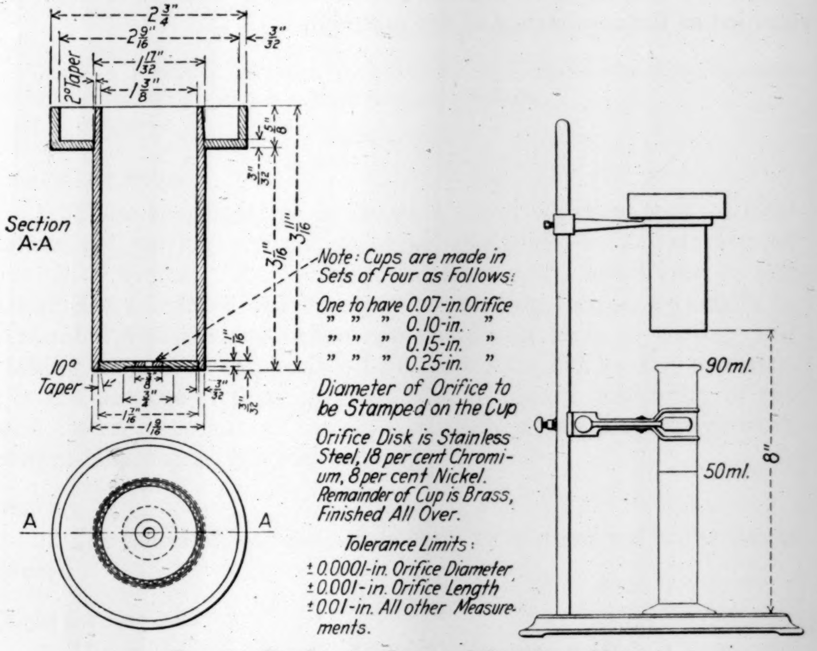
8. At least two test panels shall be exposed outdoors on an exposure rack, in full sunlight, at an angle of 45 deg. from the vertical facing south, and examined at regular intervals for color, gloss, etc., and compared with a standard panel prepared and exposed in a manner mutually agreed upon by the buyer and seller.

Non-Volatile Matter.

9. (*a*) Weigh into a flat-bottom metal or glass dish containing a stirring rod, from 4 to 6 g. of the sample to be tested, weighing in such a manner as to minimize the loss of volatile solvents. Pour in 100 ml. of acetone and stir until solution of material is complete. Add slowly 10 ml. of water, stirring vigorously. Place the dish on a hot-water bath and allow the solution to evaporate to dryness. Heat

for 1 hour in an oven at 100 to 105 C. Allow to cool 20 minutes in a desiccator and weigh. (The dish should be covered in such a manner as to allow solvents to escape and exclude contamination by dirt in the atmosphere.) If the precipitate or residue is lumpy, redissolve in the solvent combination and precipitate again with water.

(*b*) The method of determining non-volatile matter in varnishes, as described in Sections 6 and 7 of the Standard Methods of Testing Oleo-Resinous Varnishes (A.S.T.M. Designation: D 154) of the American Society for Testing Materials,[1] may be used if mutually agreed upon by the buyer and seller, with the additional requirement that the sample shall be reheated and reweighed until the weight is constant to within 0.001 g.



Note: Cups are made in Sets of Four as Follows:

One to have 0.07-in. Orifice
" " " 0.10-in. "
" " " 0.15-in. "
" " " 0.25-in. "

Diameter of Orifice to be Stamped on the Cup

Orifice Disk is Stainless Steel, 18 per cent Chromium, 8 per cent Nickel. Remainder of Cup is Brass, Finished All Over.

Tolerance Limits:
± 0.0001-in. Orifice Diameter
± 0.001-in. Orifice Length
± 0.01-in. All other Measurements.

FIG. 1.—Consistency Cups and Test Assembly.

Consistency Test Apparatus. 10. The consistency cup shall be so designed as to deliver 50 ml. of the sample in from 30 to 100 seconds. A suitable design is shown in Fig. 1.

Consistency Test Procedure. 11. The sample to be tested and the consistency cup shall be brought to a temperature of 25 C. (preferably by means of a thermostat). The consistency cup shall then be mounted in the clamp provided for the purpose and the receiving cylinder placed in position. With the outlet of the cup closed by means of the finger, the sample shall be poured into the cup until it is filled to overflowing. The excess shall then be struck off with a straight edge, the finger over the outlet removed and the sample allowed to flow into the receiving cylinder. The number of seconds from the time the finger is removed from the orifice until the top of the meniscus reaches the 50-ml. mark on the cylinder shall be determined by a stop watch and shall be recorded as the consistency of the material.

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[1] 1933 Book of A.S.T.M. Standards, Part II, p. 698.

TENTATIVE SPECIFICATIONS

FOR

WOOD TO BE USED AS PANELS IN ACCELERATED WEATHER TESTS OF PAINTS AND VARNISHES[1]

A.S.T.M. Designation: D 358 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1933.

Purpose and Scope

1. These specifications designate a wood which affords an ideal surface for testing organic finishing materials in an accelerated weathering system. According to experience, the wood used as test surface has a marked bearing upon weathering results, especially in accelerated test systems where wood failures such as slitting and cracking are greatly emphasized by most woods, but least so by cedar. It is the purpose of these specifications to obtain uniformity of the wood used for accelerated tests, particularly where cooperative work between laboratories is undertaken.

Species

2. The material for test panels shall be western red cedar (*thuja plicata*).

Weight per Cubic Foot

3. The wood shall weigh 22 to 23 lb. per cu. ft. The weight shall be determined after at least one week's storage in a protected, dry, warm atmosphere (approximately 70 F.).

Texture of Wood

4. The material shall be close grained, as nearly edge grain as possible and in no section to vary more than 45 deg. from edge grain.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. M. Rea Paul, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

TENTATIVE METHOD OF TEST
FOR
KNOCK CHARACTERISTICS OF MOTOR FUELS[1]

A.S.T.M. Designation: D 357 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1933.

Scope

1. This method is intended for determining the knock characteristics, in terms of an arbitrary scale of octane numbers, of gasolines and equivalent fuels for use in spark-ignition engines, other than engines for aircraft.

A.S.T.M. Octane Number

2. The A.S.T.M. octane number of a motor fuel is the whole number nearest to the octane number (Note 1) of that mixture of *iso*octane with normal heptane which the motor fuel matches in knock characteristics when compared by the procedure specified herein.

NOTE 1.—Octane number is defined by and is numerically equal to the percentage by volume of *iso*octane (2,2,4-trimethylpentane) in a mixture of *iso*octane and normal heptane, used as a primary standard for measurement of knock characteristics. Thus, by definition, normal heptane has an octane number of zero and *iso*octane of 100.

APPARATUS

Apparatus

3. The knock-testing unit described in this section shall be used without modification. The engine shall be known as the "C.F.R. Engine" and shall be marked[2] by plate or other approved

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[1] This method heretofore known as the C.F.R. Motor Method is based on the apparatus and procedure developed by the Cooperative Fuel Research Committee, composed of representatives of the American Petroleum Institute, National Automobile Chamber of Commerce, Society of Automotive Engineers and U. S. Bureau of Standards, who have been studying this problem since 1928.

Criticisms of this Tentative Method are solicited and should be directed to Mr. R. P. Anderson, Secretary of Committee D-2 on Petroleum Products and Lubricants, 250 Park Ave., New York City.

[2] At present the sole authorized manufacturer of the C.F.R. Engine is the Waukesha Motor Co., Waukesha, Wis. Other manufacturers may be approved in the future, but testing laboratories should not purchase engines except from Waukesha Motor Co. without ascertaining whether such engines have been approved. Inquiries in this connection should be directed to Mr. R. P. Anderson, Secretary of Committee D-2 on Petroleum Products and Lubricants, 250 Park Ave., New York City.

means with a combination of the respective emblems of the American Society for Testing Materials and the Cooperative Fuel Research Committee, thus.

The apparatus shall consist of a continuously-variable-compression motor together with suitable loading and accessory equipment as follows:

(*a*) *Engine.*—Continuously-variable-compression, one-cylinder, with dimensions as follows:

Bore, in.	3.25
Stroke, in.	4.50
Displacement, cu. in.	37.4
Valve diameter, in. clear	1.1875
Connecting-rod bearing:	
diameter, in.	2.25
length, in.	1.625
Front main bearing:	
diameter, in.	2.25
length, in.	2.00
Rear main bearing:	
diameter, in.	2.25
length, in.	4.25
Piston pin, floating, diameter, in.	1.25
Connecting rod, center to center, in.	10.00
Timing gear face, in.	1.00
Piston rings, number	5
Exhaust pipe, diameter, in.	1.25
Spark plug, size, mm	18.00
Weight of engine, lb. (approximate)	475
Weight of complete unit, lb. (approximate)	1375

(*b*) *Crankshaft.*—Fully machined, heat-treated, and counterbalanced.

(*c*) *Crankcase.*—Cast iron, with rigid end walls.

(*d*) *Connecting Rod.*—Rifle-drilled, S.A.E. No. 1045 steel, heat-treated, bearing alloy cast directly into big end.

(*e*) *Main Bearings.*—Renewable sleeve bushings, babbitt-lined.

(*f*) *Valves.*—Silcrome. Inlet valve with specially designed shroud.

(*g*) *Push Rods.*—Mushroom type with lock-nut adjustment.

(*h*) *Cylinders.*—Cast of iron alloy, bored and honed, Brinell hardness, 200 to 210.

(*i*) *Cylinder Head.*—Integral with cylinder.

(*j*) *Cooling System.*—Evaporatively cooled.

(*k*) *Lubrication.*—Pressure feed to main connecting-rod, piston-pin, and camshaft bearings, and to idler gear stud and gears.

(*l*) *Oil Heater.*—Electric heater in base to bring oil to operating temperature quickly.

(*m*) *Ignition.*—May be either a battery system or a magneto. A neon-tube spark indicator is built into the engine. Spark advance is automatically adjusted as the compression ratio is changed.

(*n*) *Carburetor.*—A special C.F.R. carburetor is furnished with the engine, and can be obtained with either two or four float bowls. The carburetor has a fixed fuel jet, shrouded by a variable air jet. Fuel containers are furnished with the carburetor.

(*o*) *Mixture Heater.*—As supplied by manufacturer, consisting of (*1*) a manifold, (*2*) an electric immersion heater and rheostat for controlling mixture temperature and (*3*) a special mercury-stem thermometer, 100 to 400° F. (38 to 204° C.), so mounted that the bulb is centered in the mixture stream to indicate the mixture temperature.

(*p*) *Instruments.*—Knock intensity is measured by a bouncing pin, in conjunction with either a knockmeter or a gas-evolution burette. Current is supplied from a small direct-current generator, belt driven from the power-absorbing unit. The knockmeter is a damped hot-wire ammeter which indicates the effective current in the circuit, thus permitting instantaneous readings. The gas-evolution burette is an electrolytic cell which integrates the impulses of current through the bouncing-pin circuit and indicates the total by the volume of gas collected in the burette in a given time.

(*q*) *Power-Absorbing Unit.*—The engine is connected by V-type belts to an electric generator. This preferably should be an induction motor with synchronous characteristics but may be any electric generator capable of maintaining proper operating conditions. In most cases the electric generator will act as a starting motor to crank the engine, but if a direct-current generator is used and no outside source of current is available, the engine may have to be cranked by hand.

(*r*) *Complete Unit.*—The complete unit may be obtained with the engine, generator, and panel board mounted on a cast-iron base plate. All necessary instruments and accessories are furnished with the unit.

Foundation

4. The foundation shall be of concrete and at least 18 in. high. If possible, it should be prepared by pouring on a concrete floor.

Proper dimensions will be furnished with the engine. For convenience in operation, the foundation should be placed at least 2 ft. from any wall. Should the floor of the building on which the engine is to be installed be other than portland-cement concrete, the floor should be cut away so that the engine foundation will rest directly on the ground. In such case the bearing area of the foundation will depend upon the condition of the underlying soil and should be such as to give ample footing.

Reference Fuels

5. *Primary Reference Fuels.*—The primary[1] reference fuels shall be *iso*octane (2,2,4-trimethylpentane), and normal heptane (Note 1). Both shall be certified for suitability as primary reference fuels by the U. S. Bureau of Standards (Note 2).

NOTE 1. *Secondary Reference Fuels.*—Mixtures of normal heptane and *iso*octane required for referee testing are expensive. For this reason secondary reference fuels may be used for routine determinations.[2] Such secondary reference fuels may be straight-run or other stable gasolines suitable for the purpose. One of the reference fuels should be of low knock rating and the other of high knock rating, or if a sufficiently high-knock-rating fuel is not available, a mixture of the higher-knock-rating fuel plus a knock suppressor may be used. These secondary reference fuels shall be calibrated on the octane-number scale against normal heptane and *iso*octane sufficiently often to insure accuracy of calibration; and for every case, whether a fuel is rated by secondary reference fuels or by means of normal heptane and *iso*octane, the result shall be recorded as an octane number.

NOTE 2.—For the present this certification consists of tests made by the Bureau of Standards on each batch of normal heptane or *iso*octane prepared respectively by the two companies mentioned[1], with certificates issued to these companies authorizing them to guarantee to the purchaser that the material shipped is a part of a batch so tested and to quote the results of the Bureau of Standards' tests.

Standard Operating Conditions

6. The engine shall be run under the following standard conditions:

(*a*) *Engine Speed.*—900 r.p.m. ± 3 r.p.m.

(*b*) *Jacket Temperature.*—Constant within ± 1° F. (0.6° C.) and at a temperature between the limits of 205 and 215° F. (96 and 102° C.).

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[1] At present, *iso*octane may be obtained from Rohm & Haas Co., 222 W. Washington Square, Philadelphia, Pa., and normal heptane from the California Chemical Co., 111 Sutter Street, San Francisco, Calif.

[2] Such secondary reference fuels are commercially available through the Standard Oil Company of New Jersey with calibration curves as determined by the supplier in accordance with this method, giving octane numbers for these fuels blended with each other and with benzene and tetraethyl lead. They may be ordered from the Standard Oil Development Co., 26 Broadway, New York City.

(*c*) *Cooling Liquid.*—Distilled water, rain water, or ethylene-glycol solution when necessary at high altitude.

(*d*) *Crankcase Lubricating Oil.*—S. A. E. 30.

NOTE.—The viscosity range of crankcase lubricating oil, S.A.E. 30, is from 185 to 255 seconds when determined on the Saybolt Universal viscosimeter at 130° F. (54.4° C.), in accordance with the Standard Methods of Test for Viscosity of Petroleum Products and Lubricants (A.S.T.M. Designation: D 88) of the American Society for Testing Materials.[1]

(*e*) *Oil Pressure.*—25 to 30 lb. per sq. in. under operating conditions.

(*f*) *Valve Clearances.*—Intake 0.008 in., cold; exhaust 0.010 in., cold.

(*g*) *Spark Advance.*—Automatically controlled:

26.0 deg. at 5:1 compression ratio (basic setting);
22.0 deg. at 6:1 compression ratio;
19.0 deg. at 7:1 compression ratio.

(*h*) *Breaker-Point Clearance.*—Battery system 0.015 in.; magneto 0.020 in.

(*i*) *Spark Plug.*—Shall conform to the standard metric plug having the tolerances and thermal characteristics equal to the No. 8 spark plug furnished by the Champion Spark Plug Co., Toledo, Ohio. Gap setting, 0.025 in.

(*j*) *Throttle Opening.*—All tests shall be conducted with the throttle opening at the point of maximum volumetric efficiency, approximately 90 on the throttle scale.

(*k*) *Carburetor Adjustment.*—For maximum knock.

(*l*) *Exhaust Pipe.*—A separate exhaust pipe should be used for each engine. This pipe should be made from 1¼-in. pipe having a maximum of two ells with a total length not to exceed 20 ft. The use of a short straight-through muffler of 1¼-in. diameter passage for prevention of noise is permissible.

(*m*) *Mixture Temperature.*—The mixture temperature shall be maintained at 300° F. ±2° F. (149° C. ±1.1° C.) as indicated by the mercury stem thermometer.

(*n*) *Bouncing Pin Assembly.*—The gap setting shall be 0.003 in. to 0.005 in.

NOTE.—The following instructions for setting of the bouncing-pin contacts should be used: With the daily inspection, observe the contact points and electrical connections to see that the points are smooth and that all the connections are tight. The gap setting should be checked (0.003-in. to 0.005-in.). The flat spring of the lower contact should touch the insulated pin with slight pressure. Too much pressure will reduce its sensitivity. To adjust the pressure accurately, set the points with 0.003-in. to 0.005-in. clearance. Then remove the diaphragm and bouncing pin. Bend the lower spring until there is from $\frac{3}{64}$-in. to $\frac{1}{16}$-in. gap between the points. Remove the upper stop-adjusting screw and bend the upper spring until there is $\frac{5}{32}$-in. gap between the points. Check the tension on the small plunger spring in upper stop-adjusting screw and see that it has from 1- to $1\frac{1}{4}$-lb. initial tension. This can be measured by pressing it against any convenient platform scale. The pin should then be re-assembled and the adjusting screw set to give 0.003-in. to 0.005-in. gap between the points. The final adjustment is made by setting the clearance so that a knockmeter reading between 50 and 60 is obtained when operating the engine at the proper knock intensity.

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[1] 1933 Book of A.S.T.M. Standards, Part II, p. 880.

PROCEDURE

Starting and Stopping the Engine

7. While the engine is being turned over by electric motor the ignition shall be turned on and the carburetor set so as to draw fuel from one float bowl. To stop the engine the fuel and the ignition switch shall be turned off and then the motor shall be stopped by means of the push-button switch. To avoid corrosion of valves and seats between operating periods the engine should be turned over by hand until both valves are closed.

Preliminary Adjustment of Compression Ratio

8. Using a mixture of 65 parts of *iso*octane and 35 parts of normal heptane, the compression ratio for first audible knock shall be obtained by increasing the compression ratio, by increments of two turns of the crank, from a point where there is no knock to the compression ratio at which audible knock is first detected. The proper knock intensity for use in making knock ratings shall be the knock intensity obtained with the mixture of 65 parts of *iso*octane and 35 parts of normal heptane when the compression ratio is increased one unit over that compression ratio giving first audible knock. Then the numerical indication of knock intensity obtained from the knockmeter or from the gas-evolution burette, whichever is used, shall be recorded. This procedure is necessary for the first adjustment only.

NOTE.—This knock intensity should be equivalent to the intensity obtained with a mixture of 65 per cent of *iso*octane and 35 per cent of normal heptane at a compression ratio of 5.3 ± 0.05 to 1 when testing at a barometric pressure of 760 mm.

For subsequent tests on fuel samples the compression ratio shall be set to duplicate this knock intensity, as indicated by the knockmeter or the gas-evolution burette, provided no change has been made in the bouncing-pin adjustment in the meantime. In no case shall the knock intensity be such that the engine does not cease firing when ignition is interrupted.

Outline of Procedure

9. The octane number of a fuel shall be ascertained by comparing the knock intensity for the fuel with those for various blends of the reference fuels until two blends differing in knock rating by not more than two octane numbers are found, one of which gives a higher knock intensity than the fuel and the other a lower knock intensity. The knock intensity shall be measured by a bouncing-pin indicator in conjunction with either a knockmeter[1] or a gas-evolution burette.

Before the test sample and the blends of the reference fuels can be compared, the compression ratio must be set to give the proper knock intensity and the carburetor adjusted to give the maximum knock for each fuel.

Adjustment of Carburetor for Fuel Under Test

10. Using the fuel whose knock rating is to be determined, the carburetor shall be adjusted as follows: After one float bowl of the carburetor has been filled with the fuel of which the octane number is to be determined, adjustment shall be made to obtain maximum knock by noting the needle valve micrometer setting and the knockmeter reading or gas evolution, then turning the micrometer screw and noting whether the knockmeter reading or gas evolution increases or decreases. The micrometer shall then be turned in the direction in which the knock increases until the knock passes through a maximum. This point shall be checked three times and the micrometer set at the position of maximum knock.

(*a*) *By Knockmeter.*—When using the knockmeter, it is unnecessary to take readings over a fixed period of time, but the knockmeter needle shall be allowed to reach equilibrium after each adjustment of the micrometer.

(*b*) *By Gas-Evolution Burette.*—At least two readings, agreeing within 5 per cent, of the volume of gas evolved over a period of 1 minute shall be taken as a measure of knock intensity.

Final Adjustment of Compression Ratio

11. Finally, adjust the compression ratio to give the same reading on the knockmeter or the gas-evolution burette when using the fuel under test as was obtained in the first adjustment under Section 8.

12. A trial blend[2] of the low-octane-number reference fuel and the high-octane-number reference fuel, based on the expected knock

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[1] The knockmeter requires less time in making tests.

[2] Extreme care is required to insure thorough mixing of ingredients.

rating of the fuel sample under test, shall be placed in another carburetor float bowl and the engine run on this trial blend. The micrometer of this float bowl shall then be adjusted to the maximum knock position in a manner similar to that described in Section 10.

Octane Number Determination

13. With the carburetor micrometers set for the air-fuel ratio of maximum knock, alternate series of readings of knock intensity shall be taken on the fuel under test and on a reference fuel blend. When using the knockmeter, the needle shall be allowed to reach equilibrium before the final reading is recorded. When using the gas-evolution burette, at least two successive 1-minute readings shall agree within 5 per cent.

At least 3 alternate series of readings shall be taken on each fuel. After changing from one fuel to another, at least 1 minute shall be allowed for the engine to reach equilibrium. With some fuels an appreciably longer time interval may be required. If the average knock intensity of the fuel sample is higher than the average of the reference fuel blend, the test shall be repeated with a blend containing a decreased proportion of the high-octane-number reference fuel.[1] The test shall be continued in this manner until the knock intensity for the fuel sample is definitely higher than one blend and lower than another blend of the reference fuels. The difference between these two final reference fuel blends shall be not more than two octane numbers.

CALCULATION

Calculation

14. The knock rating of the fuel sample shall be obtained by interpolation from the figures so recorded and the nearest whole number shall be reported as A.S.T.M. octane number.

Check of Test Conditions

15. Test conditions shall not be regarded as standard unless a blend by volume of 65 per cent *iso*octane and 35 per cent normal heptane is matched under the specified procedure by a blend by volume of 68 ± 1 per cent one-degree benzene with 32 ± 1 per cent normal heptane. At atmospheric pressure of 760 mm. a compression ratio of approximately 5.3:1 is correct for this determination. Substantial variations in atmospheric pressure will change the compression ratio required.

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[1] When changing fuels in the containers, the fuel in the container shall be drained completely by means of the drain-cock provided. A small portion of the new fuel shall be allowed to flow through the line before closing the drain-cock.

NOTE 1.—For routine checking purposes, one-degree benzene and secondary reference fuels may be used.

NOTE 2.—"One-degree" benzene[1] is a commercial product conforming to the following requirements:

(a) Boiling range not greater than 1° C., embracing the boiling point of chemically pure benzene.

(b) Specific gravity of from 0.882 to 0.886, when determined in accordance with the Standard Method of Test for Gravity of Petroleum and Petroleum Products by Means of the Hydrometer (A.S.T.M. Designation: D 287) of the American Society for Testing Materials.[2]

(c) Free from hydrogen sulfide, carbon disulfide and thiophene.

(d) Free from turbidity, with color not darker than a solution of 3 mg. of potassium dichromate in 1 liter of water when compared in 50-ml. Nessler tubes.

ACCURACY

Accuracy

16. Results obtained by this procedure with different C. F. R. engines and in different laboratories should differ by not more than two octane numbers.

While the accuracy of this method is as above stated, its sensitivity may permit detection of differences as small as 0.2 octane number when alternate readings of knock intensity are taken on the two fuels as directed in Section 13.

MAINTENANCE

Maintenance

17. It is recommended that a systematic inspection of the testing apparatus be carried out with the utmost care after each 50 hours of operation. The following points should be emphasized:

(a) *Bouncing Pin.*—Lack of sensitivity, fluctuating knockmeter reading, or irregular gas evolution may indicate diaphragm trouble. The diaphragm retaining nut should be tightened and any carbon accumulation removed. If this does not correct the condition, the diaphragm may have deteriorated and may need to be replaced.

(b) *Breaker Points.*—If necessary, pits should be removed and breaker-point clearance adjusted.

(c) *Spark Plugs.*—The porcelain should be carefully inspected for cracks, and defective plugs replaced. The spark gap shall be carefully checked and adjusted if necessary. When plugs are re-used any carbon deposit on the metal body of the plug or on the electrodes shall be removed mechanically before making gap adjustments.

(d) *Fuel System.*—Any foreign matter in the fuel containers, float bowls, lines, or carburetor shall be removed. Blowing with air and then flushing the fuel system with gasoline or benzol is a convenient method.

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[1] "One-degree" benzene may be procured from The Barrett Co., 40 Rector St., New York City.

[2] 1933 Book of A.S.T.M. Standards, Part II, p. 819.

(*e*) *Cooling System.*—Any leaks revealed by inspection shall be repaired.

(*f*) *Combustion Chamber.*—Carbon deposits shall be removed by scraping.

(*g*) *Compression Pressure.*—The cause of any abnormal change between inspections shall be investigated and corrected.

(*h*) *Valves.*—Valves shall be removed and re-ground unless there is a continuous polished line of contact on both the valve and the valve seat. After re-assembling, the valve-tappet clearances shall be carefully adjusted.

(*i*) *Piston Rings.*—Carbon shall be removed from rings and grooves.

(*j*) The intake manifold and heater blades shall be inspected and cleaned if necessary.

AMERICAN TENTATIVE STANDARD
A.S.A. No.: Z11.3-1933

TENTATIVE METHOD OF TEST
FOR
PENETRATION OF GREASES AND PETROLATUM[1]

A.S.T.M. Designation: D 217 – 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1925; REVISED, 1926, 1927, 1933.

This method has been approved as
AMERICAN TENTATIVE STANDARD
by the American Standards Association

Interpretation of Results. It should be understood that the original consistency of grease is determined by a variety of factors which are very difficult to control. The soap content is the most important single factor, but the kind of fats used, the method of mixing, the final water content, and the temperature of pouring are all very important in determining the final consistency, so that it is impracticable to maintain these consistencies within narrow limits. Any working of the sample after it is poured, or any remelting, will greatly change the consistency. The original consistency also changes to some extent on standing, changing most rapidly during the first 48 hours after manufacture and more slowly thereafter.

Although most tests in the past have been based on the original consistency of greases, this consistency bears no necessary relationship to the worked consistency which is the factor of practical importance for most uses of cup greases, etc. Tests on such greases should therefore be made on the worked consistency. It is also almost impossible to measure the unworked consistency when samples have to be taken from barrels or other large containers.

On the other hand, for very hard greases, such as railroad greases used in slab form, the original or unworked consistency is generally the property of practical importance and should be the object of the test.

Scope. 1. This method shall be used to measure the original consistency or the worked consistency of No. 0 cup grease and all harder greases and of petrolatum (unworked).

2. The method shall not be applied to greases which have been melted after having been poured and cooled during manufacture. Petrolatum, however, should be melted, poured into a suitable container and cooled before testing.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. R. P. Anderson, Secretary of Committee D-2 on Petroleum Products and Lubricants, 250 Park Ave., New York City.

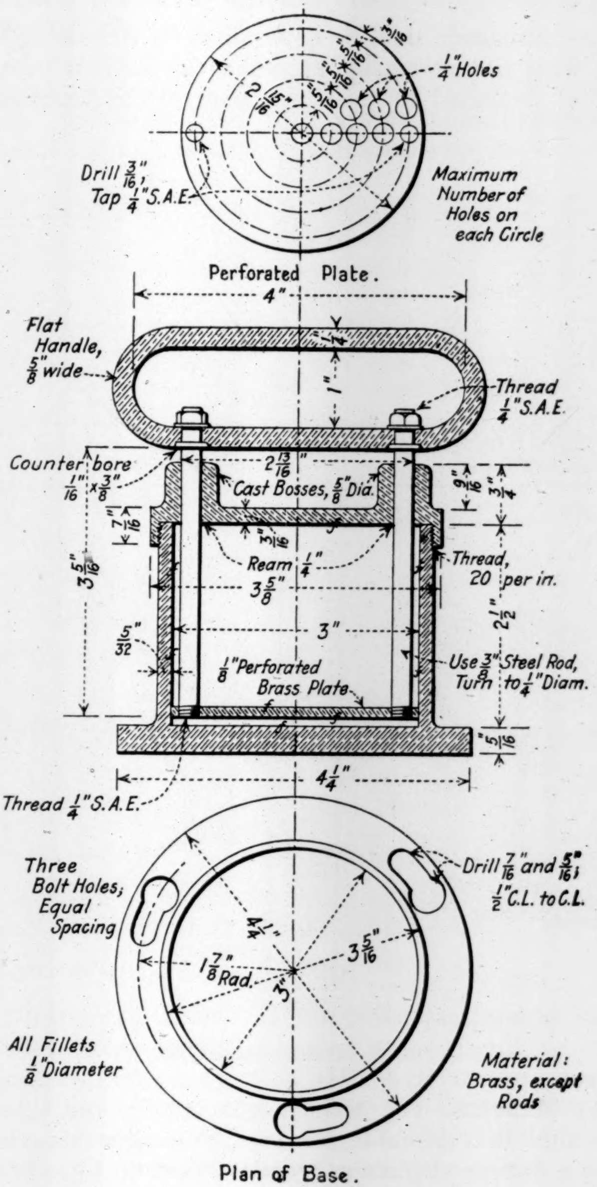
3/16"
5/16"
5/16"
5/16"
2 15/16"
1/4" Holes
Drill 3/16", Tap 1/4" S.A.E.
Maximum Number of Holes on each Circle
Perforated Plate.
4"
Flat Handle, 5/8" wide
1/4"
1"
Thread 1/4" S.A.E.
Counter bore 1/16" x 3/8"
2 13/16"
Cast Bosses, 5/8" Dia.
9/16"
3/4"
7/16"
3/16"
3 5/16"
Ream 1/4"
Thread, 20 per in.
3 5/8"
2 1/2"
3"
5/32"
Use 3/8" Steel Rod, Turn to 1/4" Diam.
1/8" Perforated Brass Plate
f
f
f
f
5/16"
4 1/4"
Thread 1/4" S.A.E.
Three Bolt Holes; Equal Spacing
Drill 7/16" and 5/16"; 1/2" C.L. to C.L.
4 1/4"
3 5/16"
1 7/8" Rad.
3"
All Fillets 1/8" Diameter
Material: Brass, except Rods
Plan of Base.

FIG. 1.—Grease Worker.

APPARATUS

Penetrometer. 3. The consistency shall be determined by measuring the penetration on what is customarily known as an asphalt penetrometer such as that described in the *Proceedings* of the American Society for Testing Materials, Vol. VII, p. 626 (1907), and illustrated in Fig. 3 herein. It is desirable, however, to modify this penetrometer by placing a flat metal plate or transite board on top of the present grid base to give a flat support for the container. If many tests are to be made, it is preferable to replace the ordinary grid base with a special flat base 6 in. in diameter.

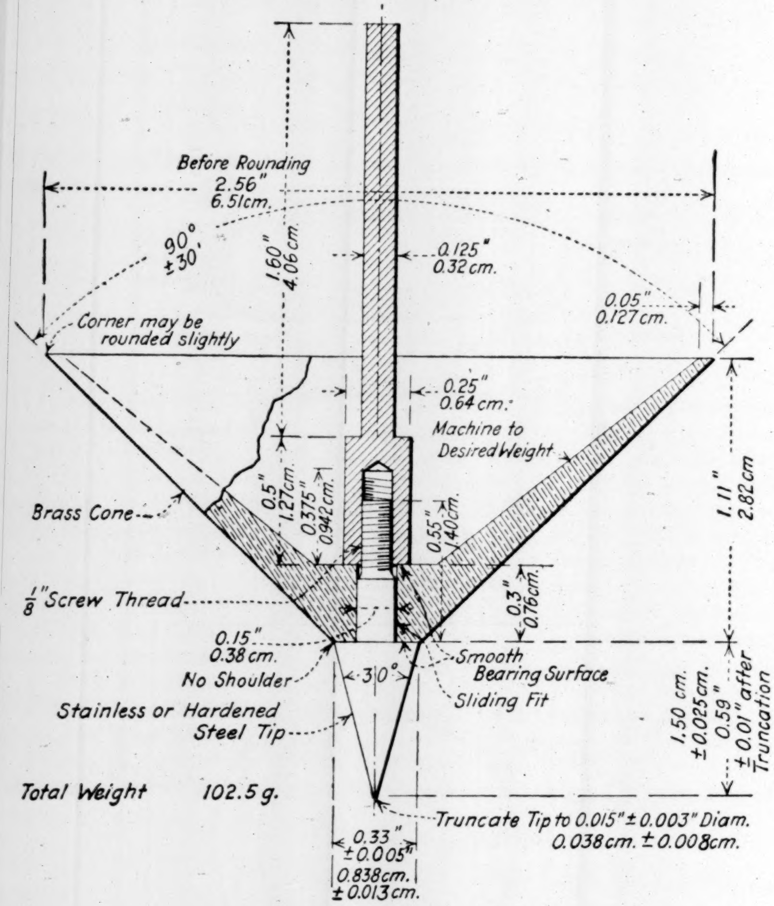
Before Rounding
2.56"
6.51cm.
90°
±30'
1.60"
4.06 cm.
0.125"
0.32 cm.
0.05"
0.127 cm.
Corner may be rounded slightly
0.25"
0.64 cm.
Machine to Desired Weight
1.11"
2.82 cm
0.5"
1.27cm.
0.375"
0.942cm.
0.55"
1.40cm.
Brass Cone
1/8" Screw Thread
0.3"
0.76cm.
0.15"
0.38 cm.
No Shoulder
30°
Smooth Bearing Surface
Sliding Fit
Stainless or Hardened Steel Tip
1.50 cm.
±0.025cm.
0.59"
±0.01" after Truncation
Total Weight 102.5 g.
Truncate Tip to 0.015" ± 0.003" Diam.
0.038 cm. ± 0.008cm.
0.33"
±0.005"
0.838cm.
±0.013 cm.

FIG. 2.—Penetrometer Cone.

This plate should have a cork insert in the center to prevent dulling the tip of the cone if it should drop.

Cone and Plunger.

4. The needle used in the asphalt penetration tests shall be replaced with the cone shown in Fig. 2.[1] The cone shall be constructed of stainless steel or of brass with a detachable hardened steel or stainless steel tip and made in accordance with the outside dimensions and tolerances shown. The interior construction and dimensions without tolerances are intended to be suggestive only. The outside surface of the cone and tip shall be given a very smooth finish.

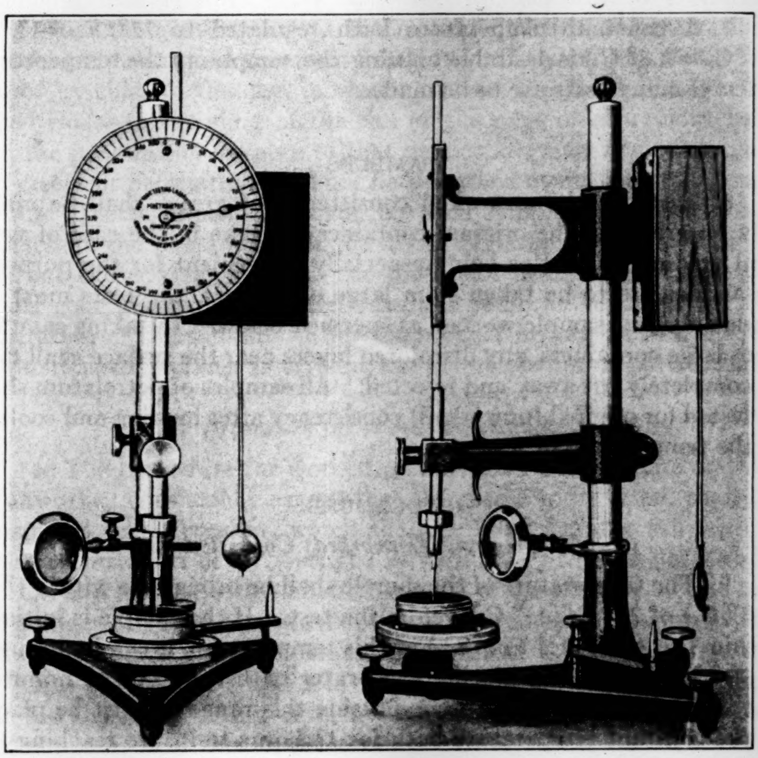

FIG. 3.—Penetrometer.

Weight.

5. The total moving weight in the test shall be 150 g. If the asphalt plunger weighs 47.5 g. (50 g. − 2.5 g. needle) the cone or the cone plus an attached weight must weigh 102.5 g. It is in general desirable to make the cone as light as possible so that it

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[1] The cone may be combined with the asphalt plunger if desired, providing the total weight of cone and plunger and the outside dimensions of the cone are not thereby changed.

will have a wide range of usefulness, and to add a weight to give the desired total for the grease test. If the conditions of the tests are not specified, the penetration of a grease shall be understood to refer to the results of this test made at 77° F. (25° C.).

Grease Worker. 6. The grease worker shown in Fig. 1 shall be used to work the grease to constant consistency in tests where the worked consistency is to be measured.

Constant Temperature Bath. 7. A constant temperature bath regulated to 77° F. ±1° F. (25° C. ±0.5° C.) is desirable to bring the samples to the temperature of test if many tests are to be made.

SAMPLES

Samples for Tests. 8. Tests on the unworked consistency of grease shall be made only on grease in the original container (or cake in the case of very hard greases), 1-lb. tins being especially convenient for the purpose. If samples are to be taken from large containers, the tests must be made only on a sample worked as specified below. In taking samples from large containers, any discolored layers near the surface shall first be completely cut away and rejected. All samples of petrolatum shall be tested for original (unworked) consistency after melting and cooling to the temperature of test.

PROCEDURE

(*A*) *Original* (*Unworked*) *Consistency*

Bringing to Temperature of Test. 9. The temperature of the sample shall be brought to within 1° F. (0.5° C.) of 77° F. (25° C.) before the test. If the sample is initially within 3 to 4° F. (1.5 to 2° C.) of this temperature, it can be brought to 77° F. (25° C.) by placing in a water bath for 30 or 40 minutes, but if the initial temperature is outside this range it must be placed in the constant temperature bath for 1½ hours to insure reaching the final constant temperature. If the room temperature is more than 3 to 4° F. (1.5 to 2° C.) from 77° F. (25° C.) a lid should be placed on the can, sealing with grease or petrolatum to prevent the entrance of water and the can immersed in the bath for the required period as, otherwise, the temperature of the surface will be different from that of the main body of the grease or petrolatum. Any holes or seams in the can should also be sealed with grease (petrolatum) or paraffin.

Preparation of Sample. 10. The surface of the grease or petrolatum shall be cut level and very smooth with a knife. Care must be taken not to work the surface of the grease or petrolatum. Any crust or discolored layers shall be completely removed before testing.

Procedure. 11. The can of grease or petrolatum shall be placed on the penetrometer table and the cone lowered until the tip just touches the surface. Watching the shadow of the tip aids in accurately setting the cone. The scale shall then be set to zero and the plunger released suddenly and kept released for five seconds. The penetration is read from the scale, the units being tenths of a millimeter.

Spacing of Tests in Cans. 12. In making tests, the total surface area disturbed by the test has a diameter about equal to the measured depth of penetration. In order to prevent one test from being affected by another disturbed area or by sides of the can, in starting a test the tip shall never be placed closer to the sides of the can or the edge of a previous hole than the penetration distance of that particular grease or petrolatum. The grease or petrolatum shall not be smoothed over for further tests.

Number of Tests Required. 13. Five tests shall be made on each sample and the average reported as the penetration, if the mean deviation of these readings does not exceed 3.0 per cent. If the mean deviation does exceed 3.0 per cent, the average of ten readings shall be reported as the penetration of the sample. More than one 1-lb. can will be needed for the required number of tests on the softer greases or petrolatums.

(*B*) *Procedure for Worked Consistency*

Procedure for Worked Consistency. 14. The procedure for worked greases shall be the same as that for unworked consistency except that the grease to be tested shall be transferred to the worker, which shall be filled heaping full with a minimum inclusion of air, brought to within 2° F. (1° C.) of 75° F. (24° C.) and worked with 60 double strokes of the plunger.[1] The top and plunger can then be removed, the surface smoothed over and the test made at once, if the temperature is within 1° F. (0.5° C.) of 77° F. (25° C.). As soon as one test is made, the surface may be smoothed over for the next, taking care to avoid creating air pockets. One 1-lb. sample is sufficient for all tests.

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[1] In general quite similar results may be obtained by working the grease thoroughly for five minutes with a spatula on a flat plate, providing care is taken to prevent working in much air. For referee tests, however, the standard worker must be used.

TENTATIVE SPECIFICATIONS
FOR
CALCIUM CHLORIDE[1]

A.S.T.M. Designation: D 98 – 33 T

This is a Tentative Standard, published for the purpose of eliciting criticism and **suggestions,** and as such is subject to annual revision.

ISSUED, 1921; REVISED, 1922, 1930, 1933.

Scope

1. These specifications cover calcium chloride to be used for road purposes, acceleration of concrete and curing of concrete.

Physical Properties

2. The calcium chloride seall be in the form of flakes and when tested by means of laboratory screens and sieves shall conform to the following requirements:

Passing ⅜-in. screen		100 per cent
Retained on ¼-in. screen	not more than 20	“
Passing No. 20 sieve	not more than 10	“

Chemical Composition

3. The calcium chloride shall conform to the following requirements as to chemical composition:

$CaCl_2$ (anhydrous)	not less than 77	per cent
$MgCl_2$	not more than 0.5	“
NaCl	not more than 2.0	“
Other impurities	not more than 1.0	“

Packing and Marking

4. The calcium chloride shall be delivered in moisture-proof bags or sacks containing approximately 100 lb. each, or in air-tight steel drums weighing not more than 450 lb. each. The name of the manufacturer, the lot number, the approximate net weight, and the percentage of calcium chloride guaranteed by the manufacturer shall be plainly marked on each container.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 801 Second Ave., New York City.

Inspection

5. Every facility shall be provided the purchaser should he elect to have his own representative sample the material at the plant. If the purchaser decides to sample the material after delivery in the field it is understood that a 3 per cent variation in content of $CaCl_2$ from the chemical composition stated in Section 3 shall be permissible.

Rejection

6. Calcium chloride shall be rejected if it fails to pass any of the requirements of these specifications and if it has become caked or sticky in the containers before opening.

TENTATIVE SPECIFICATIONS

FOR

CONCRETE FOR PAVEMENTS[1]

A.S.T.M. Designation: D 366 – 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1933.

Scope

1. These specifications cover requirements for the constituent materials, proportioning, mixing, curing and testing of concrete for use in the construction of concrete pavements. Only those construction features are included which are necessary for the proper use of the materials.

Approval of Sources of Material Supply

2. Sources of supply for portland cement, aggregates and water shall be approved by the engineer before the shipment of materials is started. Approval of sources of supply shall not be construed to be a blanket approval of all materials originating at these sources.

Retempered Concrete

3. Retempered concrete with the further addition of water shall not be used.

MATERIALS

Quality of Portland Cement

4. Portland cement shall conform to the requirements of the Standard Specifications for Portland Cement (A.S.T.M. Designation: C 9),[2] and shall be tested in accordance with the Standard Methods of Sampling and Testing Portland Cement (A.S.T.M. Designation: C 77)[3] of the American Society for Testing Materials.

Transportation of Cement

5. During transportation of cement from the proportioning plant to the mixer, provision shall be made to prevent loss or damage of the cement.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 801 Second Ave., New York City.

[2] 1933 Book of A.S.T.M. Standards, Part II, p. 3.

[3] *Ibid.*, p. 6.

Quality of Aggregates

6. Aggregates shall conform to the requirements of the Tentative Specifications for Concrete Aggregates (A.S.T.M. Designation: C 33 – 31 T) of the American Society for Testing Materials.[1] Unless otherwise specified, the coarse aggregates shall be shipped in two separate sizes and combined at the proportioning plant in the relative amounts fixed by the engineer.

Storage and Protection of Aggregates

7. Concrete aggregates shall not be placed or stored on the finished subgrade and positive means shall be used to prevent the inclusion of foreign materials. Frozen aggregates or aggregates containing lumps of frozen material shall be thawed before use. Aggregate shall be transported to the mixer in such a manner as to insure that the required amount of each class of aggregate is obtained in each batch of concrete.

Stock Piling of Aggregate

8. The formation of conical stock piles by the deposition of materials in one place will not be permitted. Stock piles of coarse aggregate exceeding 4 ft. in height shall be built up in successive horizontal layers, of which each layer shall not be more than 3 ft. in thickness. Each layer shall be completely in place before the next is started. Should the coarse aggregate become segregated, it shall be remixed so as to conform to the grading requirements of the specifications.

PROPORTIONING

Alternate Methods

9. The engineer shall specify either of the following methods of proportioning: Proportions Based on Design for Minimum Strength, Section 10, or Proportions Based on Uniform Cement Factor, Section 11.

Proportions Based on Design for Minimum Strength (Note)

Basis for Proportioning and Consistency

10. (*a*) The proportions of cement, fine aggregate, coarse aggregate and water to be used in the mix shall be fixed by the engineer on the basis of laboratory tests of concrete in which are used aggregates from the same sources and of the same gradings as will be employed in the work.

(*b*) The mixture shall be designed to produce workable concrete having a slump of not less than 1 in. nor more than 3 in. and a modulus of rupture at 28 days, as determined from specimens made, cured and tested in the laboratory by standard methods and under controlled conditions of moisture and temperature, of .... lb. per sq. in.[1]

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 750 (1931); also 1933 Book of A.S.T.M. Tentative Standards, p. 412.

(*c*) In no case shall proportions be designated which will require more than 6.0 gal. of water, including free water in the aggregates, per 94 lb. of cement.

NOTE.—In the practical application of a specification of this type it has been found that certain additional requirements are necessary in order to define accurately the duties and responsibilities of the two parties to the contract. The following additional requirements are suggested:

(*1*) The engineer will furnish prospective bidders, upon request, the proportions by weight which will be required for all aggregates from such regular established commercial sources as are available for use on the project. This information will also include the grading requirements which apply in each case.

(*2*) Immediately upon receipt of notice of award of the contract, the contractor shall furnish the engineer with the exact location of the source or sources of aggregates which he proposes to use. The proportions will then be officially designated by the engineer in accordance with Section 10. Such proportions will govern so long as materials are furnished from the sources originally designated and so long as they continue to meet the requirements hereinafter specified, subject only to slight variations in the relative quantities of fine and coarse aggregates for the purpose of securing maximum workability.

(*3*) If, during the progress of the work, the contractor wishes to use aggregates from sources other than those originally designated by him, the engineer reserves the right to change the proportions in order to meet the minimum requirements for modulus of rupture specified in Section 10 with the aggregates actually furnished.

(*4*) If, during the progress of the work, it is found impossible to obtain concrete of the proper workability with the proportions designated, the engineer may make such changes in the proportions as are necessary to secure the proper workability, provided that in no case shall the proportion of water to cement be greater than specified in the original proportions. Provided further, that the contractor shall be compensated for any additional cement required by reason of any adjustment in proportions in accordance with the following rule:

The quantity of cement to be paid for shall be calculated by deducting the theoretical cement factor (barrels of cement per cubic yard of concrete) for the original proportions from the theoretical cement factor for the revised proportions, and multiplying this by the number of cubic yards of concrete theoretically required in the section involved.

Proportions Based on Uniform Cement Factor

Basis for Proportioning and Consistency

11. (*a*) The proportions by weight of fine and coarse aggregates per bag (94 lb.) of cement shall be calculated from the values given in Table I, for the class of concrete specified by the engineer.

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[1] It is recommended that the minimum modulus of rupture specified be not less than 600 lb. per sq. in.

NOTE.—The proportions by absolute volume given in Table I are based on the maintenance of an approximately constant quantity of cement per cubic yard of concrete. The batch weights for any proportion may be determined by multiplying the absolute volumes given in Table I, first, by the apparent specific gravity of the aggregates in a saturated, surface-dry condition; second, by the weight per cubic foot of water (62.4 lb.); and third, by the number of bags of cement (94 lb. each) used in the batch. Since the weights thus calculated are for aggregates in the saturated, surface-dry condition, it will be necessary to make corrections for any other moisture conditions in the aggregates as delivered to the measuring bins. The apparent specific gravity and absorption of the fine aggregate and the coarse aggregate, and the void content (dry, rodded) of the coarse aggregate shall be determined in advance of the work by the engineer in accordance with the methods specified in Sections 23 to 25.

TABLE I.—PROPORTIONS FOR CONCRETE FOR PAVEMENTS, EXPRESSED IN ABSOLUTE VOLUMES OF AGGREGATES.

Class of Concrete	Approximate Cement Factor, Bags per cu. yd. of Concrete	Voids in Coarse Aggregate (Dry, Rodded), per cent	Cubic Feet of Aggregate by Absolute Volume to each Bag (94 lb.) of Cement			Maximum Permissible Net Water Content, gal. per 94 lb. of Cement
			Fine Aggregate	Coarse Aggregate	Total Aggregates	
Class 1	7.0	35	0.75	1.96	2.71	5.0
		40	0.90	1.81	2.71	
		45	1.05	1.66	2.71	
Class 2	6.5	35	0.83	2.11	2.94	5.5
		40	1.00	1.94	2.94	
		45	1.16	1.78	2.94	
Class 3	6.0	35	0.94	2.28	3.22	6.0
		40	1.11	2.11	3.22	
		45	1.29	1.93	3.22	
Class 4[a]	5.5	35	1.14	2.49	3.63	6.0
		40	1.33	2.30	3.63	
		45	1.52	2.11	3.63	

[a] Class 4 concrete may be used only where available aggregates have characteristics which make it possible to produce concrete of the required workability with not more than 6 gal. of water per 94 lb. of cement.

(*b*) The weights of fine and coarse aggregates may be varied from those determined from Table I in order to produce a workable concrete having a slump of not less than 1 in. nor more than 3 in. However, the total absolute volume of aggregate as given in Table I shall not be changed except as provided in Paragraph (*c*).

(*c*) The total weight of aggregates for the batch (fine aggregate plus coarse aggregate) calculated in accordance with the provisions of Paragraph (*a*) shall not be changed, unless it is found impossible to make therewith concrete of the required consistency without exceeding the maximum allowable water content as specified in Table I. In this case the batch weights shall be adjusted as directed by the engineer so as to insure that the maximum water content will not be exceeded.

(*d*) If tests made by the engineer during the progress of the work indicate that aggregates of specific gravities different from those originally determined are being furnished, the batch weights shall be adjusted to conform thereto.

MEASURING MATERIALS

Units of Measure

12. The unit of measure for cement and aggregates shall be the pound. The unit of measure for water shall be the U. S. gallon (231 cu. in.).

Measurement of Materials

13. Cement and aggregates shall be measured by weight. Cement packed in bags by the manufacturer may be assumed to weigh 94 lb., net, per bag. Water may be measured by weight or volume. The free moisture carried by the aggregates shall be considered to be a part of the mixing water and the quantity of water to be added to the batch shall be adjusted accordingly, so that the maximum water content will not exceed the specified amount. The quantitv of water to be added to the batch shall also be adjusted for water absorbed by the aggregate.

Devices for Measuring Aggregates

14. The equipment for weighing aggregates shall conform to the Specifications for the Bin Batcher Type of Equipment for Weighing Concrete Aggregates of the American Road Builders' Association.[1]

Device for Measuring Water

15. The equipment for measuring water shall be capable of accurately measuring the water to within 1 qt. ($\frac{1}{4}$ gal.) and shall be so arranged that the accuracy will not be affected by variations in pressure in the water supply line. Unless the water is to be weighed, the equipment shall include an auxiliary tank from which the measuring tank shall be filled. The volume of the auxiliary tank shall be at least equal to that of the measuring tank. The tanks shall be so arranged that the water pressure in the measuring tank cannot exceed that due to the difference in elevation between the two tanks.

MIXING

Mixer and Mixing Time

16. The concrete shall be mixed in a batch mixer which will insure a uniform distribution of the material throughout the mass,

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[1] Am. Road Builders' Assn. *Bulletin No. 15*, Section I, Part 1 (1931).

so that the mixture is uniform in color and homogeneous. The mixing of each batch shall be continued not less than 1 minute after the cement and aggregates are in the mixer, and not less than 50 seconds after the water is in the mixer, during which time the mixer shall rotate at the revolutions per minute recommended by its manufacturer.

Mixer Accessories and Capacity

17. The mixer shall be equipped with a suitable charging hopper, water storage, and a water-measuring device controlled from a case which can be kept locked and so constructed that the water can be discharged only while the mixer is being charged. It shall also be equipped with an attachment for automatically locking the discharge lever until the batch has been mixed the required length of time after all materials are in the mixer. The entire contents of the drum shall be discharged after each charge has been mixed the required length of time. The mixer shall be cleaned at frequent intervals while in use. The volume of the mixed material per batch shall not exceed the manufacturer's rated capacity of the mixer. The manufacturer shall install a plate upon the mixer stating the rated capacity and the recommended revolutions per minute.

Central and Transit Mixed Concrete

18. (*a*) Concrete mixed at a central mixing plant shall conform to the requirements of Sections 16 and 17.

(*b*) Concrete mixed or partially mixed during transportation from the materials proportioning plant to the site of the work, shall conform to the requirements of Section 20 on "Truck Mixing" of the Tentative Specifications for Ready Mixed Concrete (A.S.T.M. Designation: C 94 – 33 T) of the American Society for Testing Materials,[1] as follows:

> "In the case of truck mixers, the size of batch shall not exceed the rated capacity of the mixer as stated by the manufacturer and as stamped in metal at a prominent place on the mixer. The mixer shall be water-tight when closed. Each batch of concrete shall be mixed not less than 50 nor more than 150 revolutions of the mixer at the rate of rotation specified by the manufacturer as mixing speed. Any additional mixing shall be done at a slower speed specified by the manufacturer for agitation. The truck mixer shall be equipped with a tank for carrying the mixing water; the water shall be measured and placed in the tank at the proportioning plant, unless the tank is equipped

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[1] See p. 703.

with an automatic measuring device of the required accuracy and capable of being locked. The mixing water may be added directly to the batch, except as limited by Section 22.[1]"

(*c*) Central mixed concrete or transit mixed concrete shall conform to the requirements of Sections 21 and 22 on "Delivery" of the Tentative Specifications for Ready Mixed Concrete (A.S.T.M. Designation: C 94 – 33 T) of the American Society for Testing Materials[2] as follows:

> "Concrete shall be hauled in a water-tight container in which segregation will not take place and from which the concrete can be discharged freely and shall be delivered to the work at the consistency specified.
>
> "Concrete shall be delivered to the site of the work, and discharge from the hauling container shall be begun within a period of 1½ hr. after the introduction of the mixing water to the dry materials, or the cement to the aggregate if the fine aggregate contains surface moisture in excess of 6 per cent by weight or the coarse aggregate contains surface moisture in excess of 3 per cent by weight."

PROTECTION AND CURING

Curing

19. The concrete shall be cured by any one of the following methods of the American Society for Testing Materials as specified by the engineer as suitable for the conditions of the work:

Tentative Specifications for Curing Portland-Cement Concrete (A.S.T.M. Designation: C 80 – 31 T)[3]

Tentative Specifications for Curing Portland-Cement Concrete Slabs with Bituminous Coverings (A.S.T.M. Designation: C 81 – 31 T)[3]

Tentative Specifications for Curing Portland-Cement Concrete Slabs with Calcium-Chloride Admixture (A.S.T.M. Designation: C 82 – 31 T)[3]

Tentative Specifications for Curing Portland-Cement Concrete Slabs by Surface Application of Calcium Chloride (A.S.T.M. Designation: C 83 – 31 T)[3]

Tentative Specifications for Curing Portland-Cement Concrete Slabs with Wet Coverings (A.S.T.M. Designation: C 84 – 31 T)[3]

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[1] See Section 18 (*c*) of these specifications.

[2] See p. 707.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, pp. 756 to 762 (1931); also 1933 Book of A.S.T.M. Tentative Standards, pp. 426 to 432.

METHOD OF TESTING

Compression Tests

20. If compression tests of the concrete are required by the specifications for the project, the specimens shall be made and tested in accordance with the Standard Method of Making and Storing Compression Test Specimens of Concrete in the Field (A.S.T.M. Designation: C 31)[1] and the Standard Methods of Making Compression Tests of Concrete (A.S.T.M. Designation: C 39)[2] of the American Society for Testing Materials.

Laboratory Flexure Tests

21. Flexural strength tests to be used as the basis for the design of concrete mixtures shall be made in accordance with the Tentative Laboratory Method of Making Flexure Tests of Concrete Using a Simple Beam with Center Loading (A.S.T.M. Designation: C 78 – 30 T) of the American Society for Testing Materials.[3]

Field Flexure Tests

22. If field flexural strength tests of the concrete are required by the specifications for the project, the making and testing of the specimens shall conform to the following requirements:

(*a*) *Molding, Curing and Marking.*—The concrete for the test specimens shall be taken from the concrete deposited on the subgrade and shall be carried to the molds. The material shall not be taken at random, but each shovelful shall represent the true proportions of the mortar and coarse aggregate as they occur in the mix, and shall be taken from a batch representative of the average consistency of the concrete being placed. The molds shall be filled to overflowing and then spaded along the sides, care being used to insure that coarse aggregate is not wedged along the sides or in the corners of the forms. The top shall be carefully struck off so as to give it a true and even surface.

The specimens shall be cured in the same manner as the pavement concrete as specified in Section 19, so that the tests will directly represent the strength of the concrete in the pavement.

Specimens shall be properly identified as to date of molding and location of pavement represented. The weather conditions pertaining at the time of molding shall also be noted.

(*b*) *Number of Specimens.*—At least two beams shall be made for each 1000 sq. yd. of pavement surface.

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[1] 1933 Book of A.S.T.M. Standards, Part II, p. 225.

[2] *Ibid.*, p. 230.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 1027 (1930); also 1933 Book of A.S.T.M. Tentative Standards, p. 440.

(*c*) *Apparatus.*—The following principles shall be secured in the design of the apparatus used for making flexure tests of concrete beams, either in the field or laboratory:

1. The distance between supports and points of load application shall remain constant for a given piece of apparatus.

2. The load shall be applied normal to the initial position of the neutral plane of the beam and in such a manner as to avoid eccentricity of loading.

3. The direction of the reactions shall, at all times throughout a given test, be parallel to the direction of the applied load. If this be vertical, then the direction of the reactions shall be vertical, and shall remain so throughout the test until rupture occurs.

NOTE.—The more common devices, which, either singly or in combination, essentially secure such a relation between the applied loads and consequent reactions, include link supports, rocker bearings, spherical bearings or flexure plates.

4. The application of the load shall be such as to secure uniform increments of load for equal time periods. This operation requirement demands that the operation of the apparatus be "smooth" and free from sudden shocks.

5. The ratio of distance between point of load application and the nearest reaction to depth of beam shall be not less than $1\frac{1}{2}$ to 1.

NOTE.—The effect of this ratio on modulus of rupture requires further investigation.

Apparent Specific Gravity of Aggregates

23. (*a*) *Fine Aggregate.*—The apparent specific gravity of fine aggregate shall be determined in accordance with the Standard Method of Test for Approximate Apparent Specific Gravity of Fine Aggregate (A.S.T.M. Designation: C 68) of the American Society for Testing Materials.[1]

(*b*) *Coarse Aggregate.*—The apparent specific gravity of coarse aggregate shall be determined in accordance with the Tentative Method of Test for Apparent Specific Gravity of Coarse Aggregates in a Saturated Condition (A.S.T.M. Designation: C 86 – 31 T) of the American Society for Testing Materials.[2]

Void Content of Coarse Aggregate (Dry, Rodded)

24. The voids in dry, rodded coarse aggregate shall be calculated from the following formula:

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[1] 1933 Book of A.S.T.M. Standards, Part II, p. 242.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 766 (1931); also 1933 Book of A.S.T.M. Tentative Standards, p. 454.

$$\text{Percentage of voids} = \frac{(\text{sp. gr.} \times 62.355) - \text{Wt.}}{\text{sp. gr.} \times 62.355} \times 100$$

where sp. gr. = the apparent specific gravity of the coarse aggregate as determined in accordance with the Standard Method of Test for Apparent Specific Gravity of Coarse Aggregates (A.S.T.M. Designation: D 30) of the American Society for Testing Materials;[1]

62.355 = the weight in pounds of one cubic foot of water at the standard temperature of 16.7 C. (62 F.); and

Wt. = the weight in pounds per cubic foot of the coarse aggregate as determined in accordance with the Standard Method of Test for Unit Weight of Aggregate for Concrete (A.S.T.M. Designation: C 29) of the American Society for Testing Materials.[2]

Absorption of Aggregates

25. The absorption of aggregates shall be determined in accordance with the Tentative Method of Test for Absorption by Aggregates for Concrete (Laboratory Determinations) (A.S.T.M. Designation: C 95 - 33 T)[3] or with the Tentative Method of Field Test for Absorption of Mixing Water by Aggregates for Concrete (A.S.T.M. Designation: C 96 - 33 T) of the American Society for Testing Materials.[4]

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[1] 1933 Book of A.S.T.M. Standards, Part II, p. 994.

[2] *Ibid.*, p. 247.

[3] See p. 711.

[4] See p. 713.

TENTATIVE METHODS OF TESTING BITUMINOUS EMULSIONS[1]

A.S.T.M. Designation: D 244 – 33 T

This is a Tentative Standard, published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

Issued, 1926; Revised, 1928, 1933.

1. For testing purposes, emulsions shall be classified as follows:

- I. Emulsified light oils or liquid petroleum products intended for dust laying purposes.
- II. Emulsified asphaltic materials, the asphalt content of which is of a consistency suitable for construction or repair.
  - (*a*) Containing little or no mineral matter.
  - (*b*) Containing appreciable quantities of mineral matter.

METHOD FOR DETERMINING MISCIBILITY OF BITUMINOUS EMULSIONS WITH WATER

(Applicable to Both Classes I and II)

2. To about 50 ml. of the emulsion shall be gradually added about 150 ml. of distilled water, stirring the mixture while adding the water. The temperature is not important but should be between 21 and 25° C. (70 and 79° F.). The mixture shall be allowed to stand for 2 hours and then examined for any appreciable separation.

STONE COATING TEST

(Applicable Only to Emulsions of Class II (*a*))

3. Four hundred and sixty-five grams of clean stone ($\frac{1}{4}$ to $\frac{3}{4}$ in. in size, not more than 5 per cent passing a $\frac{1}{4}$-in. screen and 100 per cent passing a $\frac{3}{4}$-in. screen), see Tentative Specifications for Commercial Sizes of Broken Stone and Broken Slag for Highway Construction (A.S.T.M. Designation: D 63 – 23 T) of the American Society for Testing Materials,[2] of either trap or hard limestone shall be placed in a No. 10 sieve, drenched and washed with distilled water, allowed to drain for 3 minutes and transferred to a suitable pan in which the mixture is to be made. (A 6-in. hemispherical iron dish has been found suitable and satisfactory for this purpose.) Thirty-five grams of the emulsion shall then be added to and mixed vigorously with the stone for 3 minutes. (A steel spatula is satisfactory for mixing.) There shall be no signs of appreciable separation of the asphalt contained in the emulsion during the 3-minute mixing period.

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[1] Criticisms of these Tentative Methods are solicited, and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 801 Second Ave., New York City.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part I, p. 709 (1923); also 1933 Book of A.S.T.M. Tentative Standards, p. 623.

METHOD FOR DETERMINATION OF WATER, OIL DISTILLED WITH WATER AND PREPARATION OF ASPHALTIC BASE FOR FURTHER TESTS

(A) *Method Applicable to Emulsions of Class II (a) Only*

4. The apparatus shall consist of an iron still, 6 in. by 3½ in. in inside diameter with an air adjustable ring burner to fit the still. The still shall be provided with a connecting tube of approximately 12-mm. diameter glass tubing, a tin shield, a condenser trough, a condenser tube, and a suitable graduated cylinder. A thermometer 0 to 300° C. (30 to 580° F.) shall be provided conforming to the requirements for the thermometer specified in Section 6 (*a*) of the Standard Method of Test for Distillation of Gasoline, Naphtha, Kerosine, and Similar Petroleum Products (A.S.T.M. Designation: D 86) of the American Society for Testing Materials.[1] The apparatus shall be set up as shown in Fig. 1. The still shall be charged with 200 g. of the well-mixed sample. An oiled paper gasket shall be applied to the flange at the top of the still and the cover clamped on securely. The thermometer shall be placed in position so that the tip of the bulb is ½ in. from the inside bottom of the still. A gentle heat shall be applied to the top of the still by the ring burner. Just sufficient heat shall be applied to the connecting tube to prevent condensation of water therein.

The heat shall be applied to the extreme upper part of the still, until practically all of the water has distilled over, or until a temperature of 121° C. (250° F.) has been reached. The ring burner shall then be lowered very gradually to a position midway between the top and bottom of the still and held there until the temperature is about 176° C. (349° F.). The ring burner shall then be lowered more rapidly to within ¼ in. of the bottom of the still and the temperature then raised to 260° C. (500° F.) and maintained for 15 minutes. This period of heating is important to insure a smooth homogeneous residue in the still.

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[1] 1933 Book of A.S.T.M. Standards, Part II, p. 778.

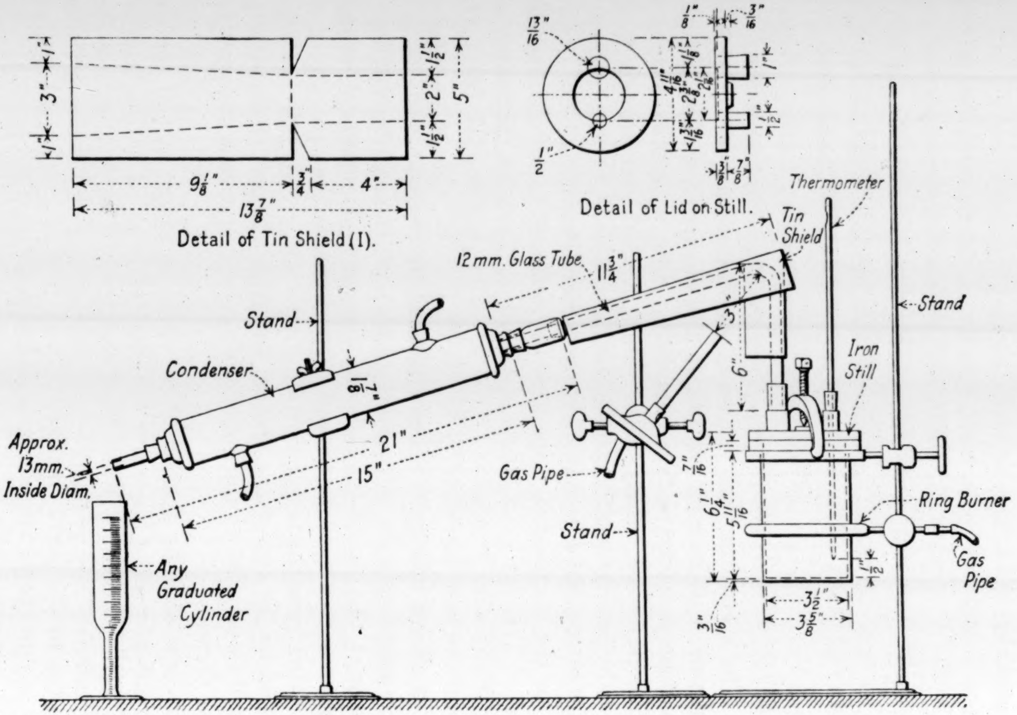
Detail of Tin Shield (I).
9 1/8"
3/4"
4"
13 7/8"
3"
1"
1 1/2"
2"
5"
Detail of Lid on Still.
13/16"
1/2"
4 11/16"
2 3/8"
1 3/16"
1 1/8"
1/8"
3/16"
3/8"
7/8"
1"
Thermometer
Tin Shield
12 mm. Glass Tube
11 3/4"
3"
6"
Stand
Iron Still
Condenser
1 7/8"
21"
15"
Approx. 13mm. Inside Diam.
Gas Pipe
7/16"
6 1/4"
5 11/16"
Ring Burner
Gas Pipe
3 1/2"
3 5/8"
3/16"
1/2"
Any Graduated Cylinder

FIG. 1.—Apparatus Assembly for Distillation Test for Bituminous Emulsions.

The cover shall then be removed from the still and the hot residue poured into a ductility mold and into a standard 3-oz. tin box for the penetration test, the receptacles being left uncovered. While cooling, any excess shall be poured into suitable containers for any additional tests desired.

Any water or oil remaining in the condenser tube shall be forced out carefully into the graduated cylinder, by means of a rubber stopper fixed on the end of a long rod.

The distillation should be completed in not less than 1 hour and in not more than 1¼ hours.

NOTE.—While the period of time for distillation should be conveniently short, the maximum suggested is not mandatory, so if a longer period of time is required for the distillation of any emulsion this shall not be considered as cause for the rejection of the material or as a departure from the intent of the method.

If the residue is not homogeneous and appears granular, it shall be rejected and the distillation repeated upon a fresh sample, maintaining the temperature at 260° C. (500° F.) for slightly more than 15 minutes.

The number of cubic centimeters of water divided by 2 is the per cent by weight of water.

The weight of residue remaining in the still divided by 2 is the percentage of non-volatile matter under the conditions of this test.

The sum of the percentage of water and non-volatile matter deducted from 100 represents distilled oils.

(*B*) *Method Applicable to Emulsions of Class II* (*b*)

Water.—The water shall be determined by the distillation method above described.

Oils.—Two 50-g. samples of well-mixed emulsion shall be placed in a standard 3-oz. tin box, in an oven at 163° C. (325° F.) for 5 hours, and the loss determined. If the loss is greater than the percentage of water (see preceding paragraph) it would indicate the presence of volatile oils and the difference in the two determinations would closely approximate the percentage of volatile oil.

The residue of the 50-g. sample shall be dissolved in benzol, filtered, and the filtrate evaporated on a water bath until practically all the benzol is evaporated, then placed in an oven at 105° C. (221° F.) for 30 minutes and finally heated on a hot plate to 121° C. (250° F.) with constant stirring. The consistency, ductility or other tests desired are made upon this residue.

Mineral Matter.—The mineral matter on the filter paper from the extraction shall be dried and weighed or a separate determination on a smaller sample of the original emulsion may be made.

TENTATIVE SPECIFICATIONS
FOR
ASPHALT CAP SHEET SURFACED WITH MINERAL GRANULES[1]

A.S.T.M. Designation: D 371 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1933.

Scope

1. These specifications cover mineral-surfaced roofing 32 or 36 in. in width, composed of roofing felt saturated and then coated on part of the width of the weather side with asphalt and surfaced with mineral granules for use as a cap sheet in the construction of built-up roofs.

Manufacture

2. In the process of manufacture, a single thickness of roofing felt shall be impregnated with an asphaltic saturant, then coated on one side for 1 in. less than one half of the width with an asphaltic coating and finally surfaced with mineral granules.

Character of Felt

3. The felt shall be a roofing felt produced by "felting" vegetable and animal fibers. The surface of the felt shall be uniformly smooth and, upon splitting or tearing on the bias, shall appear reasonably free from lumps of underbeaten stock (that is, stock which has not been beaten or shredded into fiber in the process of manufacture) and particles of foreign substances (that is, fragments of stone, metal, leather, rubber, straw, wood, etc.).

Character of Saturant and Coatings

4. The saturant and coatings shall be composed principally of asphaltic materials, and the presence of saponifiable constituents shall be permitted.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-8 on Bituminous Waterproofing and Roofing Materials, 801 Second Ave., New York City.

Character of Felt After Saturation

5. The felt shall be thoroughly and uniformly saturated, and shall show no unsaturated spots at any point upon cutting 2-in. strips at random across the entire sheet and splitting them open for their full length.

Character of Mineral Surfacing

6. The surfacing on the weather side of the sheet shall be granular crushed slate or similar mineral material, as may be specified by the purchaser (in either green, red, blue-black or such other color or combinations of color as may be mutually agreed upon between the purchaser and vendor). The mineral surfacing shall be sufficiently free from fines or dust to permit the firm adhesion of the larger particles of the surfacing and provide a uniform distribution.

Physical Properties

7. The fabricated product shall conform to the following requirements:

Width of roll		32 or 36 in. ± $\frac{1}{4}$ in.
Area of roll[a]	32 in. width	107.3 sq. ft. ± 5 per cent
	36 in. width	106.8 sq. ft. ± 5 per cent
Weight of wrapping and packing per roll		1 lb., max.
Weight of material per roll (Exclusive of wrapping, packing and loose mineral surfacing)		55 lb., avg. 52 lb., min.
Pliability at 77 F. (25 C.)		At least 8 out of 10 strips shall not crack when bent 90 deg. at a uniform speed over a rounded corner of $\frac{3}{4}$-in. radius.
Behavior on heating to 176 F. (80 C.) for 2 hr.		1.5 per cent volatile matter, max. There shall be no flowing, sagging, blistering, or absorption of the surface coatings. Granular surfacings shall not slide more than $\frac{1}{16}$ in. when suspended vertically.
Saturant in moisture-free felt		150 per cent, min., by weight
Weight of moisture-free desaturated felt per 108 sq. ft.		10.8 lb., min. ("Number" 48)
Ash in moisture-free desaturated felt		12 per cent, max., by weight.
Weight of mineral surfacing and mineral matter in coatings per 108 sq. ft. of coated and surfaced area		45 lb., max.

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[a] Sufficient to cover 50 sq. ft. of roof surface.

Finished Appearance

8. The weather surface shall be uniform in finish and texture.

Freedom from Defects

9. The finished product shall be free from visible external defects, such as holes, ragged or untrue edges, breaks, cracks, tears, protuberances and indentations.

Distribution of Coatings and Surfacings

10. The asphaltic coating and mineral granules shall be applied in a uniformly smooth layer on the weather surface for 1 in. less than one half of the width.

Adhesion of Surfacing

11. The granular surfacing shall be embedded in the asphaltic coating in such a manner that when rubbed vigorously with the hand, sufficient surfacing will remain embedded to completely cover the coating.

Stickiness

12. The coating and surfacing shall be of such a nature that the finished product will not crack or be sticky enough to cause tearing or damage upon being unrolled at atmospheric temperatures above 50 F. (10 C.).

Packing Cap Sheets

13. Cap sheets shall be put up in rolls, containing sufficient material to cover 50 sq. ft. No rolls shall contain more than two pieces nor shall there be more than 3 per cent of rolls containing two pieces in any shipment. The rolls shall be tightly wound and securely wrapped in a substantial grade of paper. The wrapper shall completely encircle the roll and shall be pasted at the overlap in a manner which will prevent it from shifting from position. The ends of the roll shall be protected with metal caps, cloth, or other suitable means. Rolls for export shipment shall be packed as mutually agreed upon by the purchaser and vendor.

Sampling and Testing

14. The material shall be sampled and the properties enumerated in these specifications shall be determined in accordance with the Tentative Methods of Testing Asphalt Roll-Roofing Surfaced with Fine Talc, Granular Talc or Mineral Granules; also Asphalt Shingles Surfaced with Mineral Granules (A.S.T.M. Designation: D 228 - 33 T) of the American Society for Testing Materials.[1]

Inspection

15. Inspection of material shall be made as mutually agreed upon by the purchaser and vendor as part of the purchase contract.

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[1] See p. 799.

TENTATIVE SPECIFICATIONS

FOR

HEAVY WEIGHT ASPHALT ROLL-ROOFING AND HEAVY WEIGHT ASPHALT SHINGLES SURFACED WITH MINERAL GRANULES[1]

A.S.T.M. Designation: D 249 – 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

Issued as Tentative, 1926; Adopted, 1927; Reissued as Tentative, 1933.

Scope. 1. These specifications cover mineral-surfaced roll-roofing, either 36 or 32 in. in width, and mineral composition shingles, composed of roofing-felt saturated and coated on both sides with asphalt and surfaced on the weather side with granulated slate (green, red, blue-black, or such other color or combinations of color as may be agreed upon between the purchaser and seller), or similar mineral material to be specified by the purchaser, and on the reverse side with powdered talc or mica to prevent the roofing or shingles adhering together in the package. Such roofing and shingles are intended for use on semi-permanent and permanent buildings.

MANUFACTURE

Manufacture. 2. In the process of manufacture, a single thickness of dry roofing felt shall be impregnated with an asphaltic saturant, then coated on both sides with an asphaltic coating, and finally surfaced on the weather side with granulated slate or similar mineral material to be specified by the purchaser, and on the reverse side with powdered talc or mica.

Character of Felt. 3. The felt shall be a roofing felt produced by "felting" vegetable and animal fibers. The surface of the felt shall be uniformly smooth and, upon splitting or tearing on the bias, shall appear reasonably free from lumps of underbeaten stock (*i.e.*, stock which has not been beaten or shredded into fiber in the process of manufacture) and particles of foreign substances (*i.e.*, fragments of stone, metal, leather, rubber, straw, wood, etc.).

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[1] **Criticisms** of these Tentative Specifications are **solicited** and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-8 on Bituminous Waterproofing and Roofing Materials, 801 Second Ave., New York City.

These specifications are in effect a revision of the former Standard Specifications for Heavy Weight Asphalt Roll-Roofing and Heavy Weight Asphalt Shingles Surfaced with Mineral Granules (A.S.T.M. Designation: D 249 – 27), which standard was accordingly discontinued in 1933.

Character of Saturant and Coatings.

4. The saturant and coatings shall be composed principally of asphaltic materials, and the presence of saponifiable constituents shall be permitted.

Character of Felt after Saturation.

5. The felt shall be thoroughly and uniformly saturated, and shall show no unsaturated spots at any point upon cutting 2-in. strips at random across the entire sheet and splitting them open for their full length.

Character of Mineral Surfacing.

6. The surfacing on the weather side shall be granular crushed slate or similar mineral material, as may be specified by the purchaser (in either green, red, blue-black or such other color or combinations of color as may be agreed upon between the purchaser and seller), shall be sufficiently free from fines or dust to permit the firm adhesion of the larger particles of the surfacing and provide a uniform distribution. The under side of the sheet shall be surfaced with a non-combustible material such as powdered mica or talc.

PHYSICAL PROPERTIES

Physical Properties.

7. The fabricated product shall conform to the following requirements:

(*a*) *Width of Roll: Size and Form of Shingles.*—Slate roll-roofing shall be either 36 or 32 in. in width, as may be specified, $\frac{1}{4} \pm$ in.

Shingles shall be of a size and form as may be agreed upon between the purchaser and seller.

(*b*) *Area per Package: Mineral-Surfaced Roll.*—The average area of the rolls examined shall contain not less than 108 sq. ft., which shall be sufficient to cover one "square."

Shingles.—Sufficient material shall be furnished per "square" as may be agreed upon between the purchaser and seller to adequately waterproof, when laid, the surface to which the shingles are applied.

(*c*) *Weight of Wrapping and Packing Material per "Square": Mineral-Surface Roll* including nails and lap-cement, maximum, 4 lb.

NOTE.—Special fixtures may be furnished in lieu of nails and cement, if agreed upon by the purchaser and seller, in which event the above weight may be increased.

Shingles (packing only), maximum, 12 lb.

(*d*) *Weight of Material per 108 sq. ft. Exclusive of Wrapping, Packing, Loose Mineral Surfacing, Nails and Cement:*

Mineral-Surfaced Roll and Shingles.—Average, 105 lb., minimum, 100 lb.

(*e*) *Pliability at 77° F. (25° C.): Mineral-Surfaced Roll and Shingles.*—No requirements.

(*f*) *Behavior on Heating to 176° F. (80° C.) for 2 hours.*—Volatile matter, maximum 1.5 per cent. There shall be no flowing, sagging, blistering or absorption of the surface coatings. Granular surfacings shall not slide more than $\frac{1}{16}$ in. when suspended vertically.

(*g*) *Saturant in Moisture-Free Felt:*

Mineral-Surfaced Roll.—Minimum, 160 per cent by weight.

Shingles.—Minimum, 175 per cent by weight.

(*h*) *Weight of Moisture-Free Desaturated Felt per 108 sq. ft.:*

Mineral-Surfaced Roll and Shingles.—Minimum, 15.75 lb. ("Number" 70).

(*i*) *Ash in Moisture-Free Desaturated Felt.*—Maximum, 12 per cent by weight.

(*j*) *Weight of Mineral Surfacings and Mineral Matter in Coating per 108 sq. ft.: Roll and Shingles.*—Maximum, 40 lb.

WORKMANSHIP AND FINISH

Finished Appearance. Freedom from Defects.

8. The weather surface shall be uniform in finish and texture.

9. The finished product shall be free from visible external defects, such as holes, ragged or untrue edges, breaks, cracks, tears, protuberances and indentations.

Distribution of Coatings and Surfacing.

10. The coating and granules shall be applied in a uniformly smooth layer over the entire weather surface, except that slate-roll roofing may be provided with a bare lapping edge, 2 in. wide, along one edge of the sheet, where either the slate alone, or both the slate and coating may be omitted. The under surface of the sheet shall have the asphalt coating and mineral surfacing applied uniformly to the edges.

Adhesion of Surfacing.

11. The granular surfacing shall be embedded in the coating in such a manner that when rubbed vigorously with the hand, sufficient surfacing will remain embedded to completely cover the coating.

Stickiness.

12. For mineral-surfaced roll-roofing, the coating and surfacings shall be of such a nature that the finished product will not crack or stick together so as to cause tearing or damage upon being unrolled at atmospheric temperatures above 50° F. (10° C.). For shingles, the coating and surfacings shall be of such a nature that the finished prod-

ucts will not adhere together in the bundles so as to tear off or loosen the coating when unpacked.

PACKING

Roll-Roofing. 13. (*a*) Mineral-surfaced roll-roofing shall be put up in rolls of 108 sq ft. No rolls shall contain more than two pieces nor shall there be more than 3 per cent of rolls containing two pieces in any shipment. The rolls shall be tightly wound and securely wrapped in a substantial grade of paper. The wrapper shall completely encircle the roll and shall be pasted at the overlap in a manner which will prevent it shifting from position. The ends of the roll shall be protected with metal caps, cloth or other suitable means. The nails and lap-cement shall be furnished either in each roll or in bulk, as specified in the order. When furnished in bulk, the cloth or metal ends may be omitted. Rolls for export shipment shall be packed as agreed upon by the purchaser and seller.

Shingles. (*b*) Shingles shall be packed in bundles weighing not more than 135 lb. gross. The bundles shall either be packed in cardboard cartons or between wooden or cardboard ends and tied with rope, wire or steel bands so as to make a substantial package, as may be agreed upon by the purchaser and seller. Each roll or package shall be plainly marked with the manufacturer's name and brand or as agreed upon by the purchaser and seller, and shall contain printed directions for laying.

Nails. 14. (*a*) *Nails.*—The gage of the wire shall not be greater than "A. S. & W." No. 10 (0.135 in.) nor thinner than No. 12 (0.105 in.); the head shall be not less than $\frac{3}{8}$ in. in diameter, and not less than 0.025 in. in thickness; the shank shall be between $\frac{3}{4}$ and 1 in. long for roll-roofing, and for shingles 1 in. long when laid on solid sheathing, or $1\frac{1}{2}$ to $1\frac{3}{4}$ in. when laid over old shingles. The lower end of the shank shall be pointed, and either smooth or barbed, and if the latter, then the barbings shall not increase the diameter of the lower two-thirds more than 0.01 in. The nails shall be zinc coated with not less than $\frac{1}{2}$ oz. nor more than $1\frac{1}{4}$ oz. per sq. ft. of nail surface. Hot-galvanized, electrogalvanized, or sherardized coatings will be accepted. There shall be furnished per "square" of roll-roofing not less than an average of 252 nails for 36-in., and not less than an average of 275 nails for 32-in. roofing. For shingles, the nails shall be purchased separately, and the number required per "square" will depend upon the size and form of the shingles and shall be agreed upon by the purchaser and seller.

Cement.

(*b*) *Lap-Cement* (*for Mineral-Surfaced-Roll*).—The cement shall be composed of bituminous materials dissolved in a volatile solvent, and shall be of such a nature as to firmly bind the laps without injurious effect upon the roofing. The cement shall have a minimum flash point of 71° F. (21.5° C.) when tested by the Tagliabue Closed-Cup Tester. There shall be furnished for each square of 36-in. roofing not less than $\frac{3}{4}$ pint and for 32-in. roofing not less than 1 pint. The addition of 5 to 20 per cent by weight of short-fibered asbestos shall be permitted, in which case the quantity of cement shall be increased $\frac{1}{4}$ pint per "square."

SAMPLING AND TESTING

Sampling and Testing.

15. The material shall be sampled and the properties enumerated in these specifications shall be determined in accordance with the Tentative Methods of Testing Asphalt Roll-Roofing Surfaced with Fine Talc, Granular Talc or Mineral Granules; also Asphalt Shingles Surfaced with Mineral Granules (A.S.T.M. Designation: D 228 – 33 T) of the American Society for Testing Materials.[1]

INSPECTION

Inspection.

16. Inspection of material shall be made as agreed upon by the purchaser and seller as part of the purchase contract.

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[1] See p. 799.

TENTATIVE SPECIFICATIONS
FOR
ASPHALT ROLL-ROOFING AND ASPHALT SHINGLES SURFACED WITH MINERAL GRANULES[1]

A.S.T.M. Designation: D 225 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED AS TENTATIVE, 1925; ADOPTED IN AMENDED FORM, 1927; REVISED, 1929; REISSUED AS TENTATIVE, 1933.

Scope. 1. These specifications cover mineral-surfaced roll-roofing, either 36 or 32 in. in width, and mineral composition shingles, composed of roofing-felt saturated and coated on both sides with asphalt and surfaced on the weather side with granulated slate (green, red, blue-black, or such other color or combinations of color as may be agreed upon between the purchaser and seller), or similar mineral material to be specified by the purchaser, and on the reverse side with powdered talc or mica to prevent the roofing or shingles adhering together in the package. Such roofing and shingles are intended for use on semi-permanent and permanent buildings.

MANUFACTURE

Manufacture. 2. In the process of manufacture, a single thickness of dry roofing felt shall be impregnated with an asphaltic saturant, then coated on both sides with an asphaltic coating, and finally surfaced on the weather side with granulated slate or similar mineral material to be specified by the purchaser, and on the reverse side with powdered talc or mica.

Character of Felt. 3. The felt shall be a roofing felt produced by "felting" vegetable and animal fibers. The surface of the felt shall be uniformly smooth and, upon splitting or tearing on the bias, shall appear reasonably free from lumps of underbeaten stock (*i.e.*, stock which has not been beaten or shredded into fiber in the process of manufacture) and particles of foreign substances (*i.e.*, fragments of stone, metal, leather, rubber, straw, wood, etc.).

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-8 on Bituminous Waterproofing and Roofing Materials, 801 Second Ave., New York City.

These specifications are in effect a revision of the former Standard Specifications for Asphalt Roll-Roofing and Asphalt Shingles Surfaced with Mineral Granules (A.S.T.M. Designation: D 225 - 29), which standard was accordingly discontinued in 1933.

4. The saturant and coatings shall be composed principally of asphaltic materials, and the presence of saponifiable constituents shall be permitted. **Character of Saturant and Coatings.**

5. The felt shall be thoroughly and uniformily saturated, and shall show no unsaturated spots at any point upon cutting 2-in. strips at random across the entire sheet and splitting them open for their full length. **Character of Felt after Saturation.**

6. The surfacing on the weather side shall be granular crushed slate or similar mineral material, as may be specified by the purchaser (in either green, red, blue-black or such other color or combinations of color as may be agreed upon between the purchaser and seller), shall be sufficiently free from fines or dust to permit the firm adhesion of the larger particles of the surfacing and provide a uniform distribution. The under side of the sheet shall be surfaced with a non-combustible material such as powered mica or talc. **Character of Mineral Surfacing.**

PHYSICAL PROPERTIES

7. The fabricated product shall conform to the following requirements: **Physical Properties**

(*a*) *Width of Roll; Size and Form of Shingles:* Mineral-surfaced roll-roofing shall be either 36 or 32 in. in width, as may be specified, ± $\frac{1}{4}$ in.

Shingles shall be of a size and form as may be agreed upon between the purchaser and seller.

(*b*) *Area per Package: Mineral Surfaced Roll.*—The average area of the rolls examined shall contain not less than 108 sq. ft., which shall be sufficient to cover one "square."

Shingles.—Sufficient material shall be furnished per "square" as may be agreed upon between the purchaser and seller to adequately waterproof, when laid, the surface to which the shingles are applied.

(*c*) *Weight of Wrapping and Packing Material per "Square": Mineral-Surfaced Roll* including nails and lap-cement, maximum, 4 lb.

NOTE.—Special fixtures may be furnished in lieu of nails and cement, if agreed upon by the purchaser and seller, in which event the above weights may be increased.

Shingles (packing only), maximum 15 lb.

(*d*) *Weight of Material per 108 sq. ft. Exclusive of Wrapping, Packing, Loose Mineral Surfacing, Nails and Cement: Mineral-Surfaced Roll.*—Average, not less than 82 lb.; minimum, 80 lb.

Shingles.—Average, not less than 85 lb.; minimum, 83 lb.

(*e*) *Pliability at 77° F. (25° C.): Mineral-Surfaced Roll.*—At least four strips out of five shall not crack on a 25-mm. mandrel.

Shingles.—No requirements.

(*f*) *Behavior on Heating to 176° F. (80° C.) for 2 hours.*—Volatile matter, maximum 1.5 per cent. There shall be no flowing, sagging, blistering or absorption of the surface coatings. Granular surfacings shall not slide more than $\frac{1}{16}$ in. when suspended vertically.

(*g*) *Saturant in Moisture-Free Felt:*

Mineral-Surfaced Roll, minimum, 150 per cent by weight.

Shingles, minimum, 175 per cent by weight.

(*h*) *Weight of Moisture-Free Desaturated Felt per 108 sq. ft.*—Mineral-surfaced roll and shingles, minimum 10.8 lb. ("Number" 48).

(*i*) *Ash in Moisture-Free Desaturated Felt.*—Maximum, 12 per cent by weight.

(*j*) *Weight of Mineral Surfacings and Mineral Matter in Coating per 108 sq. ft.*—Roll and shingles, maximum, 35 lb.

NOTE.—Should the weight exceed the above amount, the material shall nevertheless be acceptable provided the finished weight per 108 sq. ft. is increased by a like amount over the requirements specified in Paragraph (*d*).

WORKMANSHIP AND FINISH

Finished Appearance. 8. The weather surface shall be uniform in finish and texture.

Freedom from Defects. 9. The finished product shall be free from visible external defects, such as holes, ragged or untrue edges, breaks, cracks, tears, protuberances and indentations.

Distribution of Coatings and Surfacings. 10. The coating and granules shall be applied in a uniformly smooth layer over the entire weather surface, except that roll roofing may be provided with a bare lapping edge, 2 in. wide, along one edge of the sheet, where either the slate alone, or both the slate and coating may be omitted. The under surface of the sheet shall have the asphalt coating and mineral surfacing applied uniformly to the edges.

Adhesion of Surfacing. 11. The granular surfacing shall be embedded in the coating in such a manner that when rubbed vigorously with the hand, sufficient surfacing will remain embedded to completely cover the coating.

Stickiness. 12. For mineral surfaced roll-roofing, the coating and surfacings shall be of such a nature that the finished product will not crack or stick together so as to cause tearing or damage upon being unrolled at atmospheric temperatures above 50° F. (10° C.). For shingles, the coating and surfacings shall be of such a nature that the finished products will not adhere together in the bundles so as to tear off or loosen the coating when unpacked.

PACKING

Roll-Roofing. 13. (*a*) Mineral-surfaced roll-roofing shall be put up in rolls of 108 sq. ft. No rolls shall contain more than two pieces nor shall there be more than 3 per cent of rolls containing two pieces in any shipment. The rolls shall be tightly wound and securely wrapped in a substantial grade of paper. The wrapper shall completely encircle the roll and shall be pasted at the overlap in a manner which will prevent it shifting from position. The ends of the roll shall be protected with metal caps, cloth or other suitable means. The nails and lap-cement shall be furnished either in each roll or in bulk, as specified in the order. When furnished in bulk, the cloth or metal ends may be omitted. Rolls for export shipment shall be packed as agreed upon by the purchaser and seller.

Shingles. (*b*) Shingles shall be packed in bundles weighing not more than 135 lb. gross. The bundles shall either be packed in cardboard cartons or between wooden or cardboard ends and tied with rope, wire or steel bands so as to make a substantial package, as may be agreed upon by the purchaser and seller. Each roll or package shall be plainly marked with the manufacturer's name and brand or as agreed upon by the purchaser and seller, and shall contain printed directions for laying.

Nails. 14. (*a*) *Nails.*—The gage of the wire shall not be greater than "A. S. & W." No. 10 (0.135 in.) nor thinner than No. 12 (0.105 in.); the head shall not be less than 3/8 in. in diameter, and not less than 0.025 in. thick; the shank shall be between 3/4 and 1 in. long for roll roofing, and for shingles 1 in. long when laid on solid sheathing, or 1½ to 1¾ in. when laid over old shingles. The lower end of the shank shall be pointed, and either smooth or barbed, and if the latter, then the barbings shall not increase the diameter of the lower two-thirds more than 0.01 in. The nails shall be zinc coated with not less than ½ oz. nor more than 1¼ oz. per sq. ft. of nail surface. Hot-galvanized, electrogalvanized, or sherardized coatings will be accepted. There shall be furnished per "square" of roll roofing not less than an average of 252 nails for 36 in., and not less than an average of 275 nails for 32-in. roofing. For shingles, the nails shall be purchased separately, and the number required per "square" will depend upon the size and form of the shingles and shall be agreed upon by the purchaser and seller.

Cement.

(*b*) *Lap-cement* (*for Mineral-Surfaced Roll*).—The cement shall be composed of bituminous materials dissolved in a volatile solvent, and shall be of such a nature as to firmly bind the laps without injurious effect upon the roofing. The cement shall have a minimum flash point of 71° F. (21.5° C.) when tested by the Tagliabue Closed-Cup Tester. There shall be furnished for each square of 36-in. roofing not less than ¾ pint and for 32-in. roofing not less than 1 pint. The addition of 5 to 20 per cent by weight of short-fibered asbestos shall be permitted, in which case the quantity of cement shall be increased ¼ pint per "square."

SAMPLING AND TESTING

Sampling and Testing.

15. The material shall be sampled and the properties enumerated in these specifications shall be determined in accordance with the Tentative Methods of Testing Asphalt Roll-Roofing Surfaced with Fine Talc, Granular Talc or Mineral Granules; also Asphalt Shingles Surfaced with Mineral Granules (A.S.T.M. Designation: D 228 – 33 T) of the American Society for Testing Materials.[1]

INSPECTION

Inspection.

16. Inspection of material shall be made as agreed upon by the purchaser and seller as part of the purchase contract.

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[1] See p. 799.

TENTATIVE SPECIFICATIONS
FOR
ASPHALT ROLL-ROOFING SURFACED WITH GRANULAR TALC[1]

A.S.T.M. Designation: D 248 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED AS TENTATIVE, 1926; ADOPTED, 1927; REISSUED AS TENTATIVE, 1933.

Scope. 1. These specifications cover roll-roofing (medium and heavy weights) either 36 or 32 in. in width, composed of roofing felt saturated and coated on both sides with asphalt, and surfaced on the face with granular talc, and on the back with powdered talc or mica. The medium weight is intended for use on semi-permanent structures, and the heavy weight on permanent structures.

MANUFACTURE

Manufacture. 2. In the process of manufacture, a single thickness of dry roofing felt shall be impregnated with an asphaltic saturant, then coated on both sides with an asphaltic coating, and finally surfaced on the weather side with granular talc, and on the reverse side with powdered talc or mica.

Character of Felt. 3. The felt shall be a roofing felt produced by "felting" vegetable and animal fibers. The surface of the felt shall be uniformly smooth and, upon splitting or tearing on the bias, shall appear reasonably free from lumps of underbeaten stock (*i.e.*, stock which has not been beaten or shredded into fiber in the process of manufacture) and particles of foreign substances (*i.e.*, fragments of stone, metal, leather, rubber, straw, wood, etc.).

Character of Saturant and Coatings. 4. The saturant and coatings shall be composed principally of asphaltic materials, and the presence of saponifiable constituents shall be permitted.

Character of Felt after Saturation 5. The felt shall be thoroughly and uniformly saturated and shall show no unsaturated spots at any point upon cutting 2-in. strips at random across the entire sheet and splitting them open for their full length.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-8 on Bituminous Waterproofing and Roofing Materials, 801 Second Ave., New York City.

These specifications are in effect a revision of the former Standard Specifications for Asphalt Roll-Roofing Surfaced with Granular Talc (A.S.T.M. Designation: D 248 - 27), which standard was accordingly discontinued in 1933.

Character of Mineral Surfacing.

6. The surfacing on the weather side of the sheet shall be coarsely crushed talc and of a color as may be agreed upon between the purchaser and seller. It shall be of such a character as to permit the firm adhesion of the larger particles of surfacing and provide a uniform distribution. The under side of the sheet shall be surfaced with a non-combustible material such as powdered mica or talc.

PHYSICAL PROPERTIES

Physical Properties.

7. The fabricated product shall conform to the following requirements:

(a) *Width of Roll.*—Either 36 or 32 in., as may be specified, ±¼ in.

(b) *Area of Roll.*—The average area of the rolls examined shall contain, as specified, not less than either 108 sq. ft. or 216 sq. ft., which shall be sufficient to cover one or two "squares" respectively.

(c) *Weight of Wrapping, Packing, Nails and Cement per "Square."*—Maximum, 4 lb.

NOTE.—Special fixtures may be furnished in lieu of nails and cement, if agreed upon by the purchaser and seller, in which event the above weight may be increased.

(d) *Weight of Material per 108 sq. ft. Exclusive of Wrapping Packing, Loose Mineral Surfacing, Nails and Cement:*
Medium Weight, average, 52 lb.; minimum, 50 lb.
Heavy Weight, average, 62 lb.; minimum, 59 lb.

(e) *Pliability at 77° F. (25° C.).*—At least eight strips out of ten shall not crack when bent 90 deg. at a uniform speed over a rounded corner of ½-in. radius.

(f) *Behavior on Heating to 176° F. (80° C.) for 2 hours.*—Volatile matter, maximum, 1.5 per cent. There shall be no flowing, sagging, blistering or absorption of the surface coatings.

(g) *Saturant in Moisture-Free Felt.*—Medium and Heavy Weights, minimum, 150 per cent by weight.

(h) *Weight of Moisture-Free Desaturated Felt per 108 sq. ft.*—
Medium weight, minimum, 10.8 lb. ("Number" 48).
Heavy weight, minimum, 13.5 lb. ("Number" 60).

(i) *Ash in Moisture-Free Desaturated Felt.*—Maximum, 12 per cent by weight.

(*j*) *Weight of Mineral Surfacings and Mineral Matter in Coatings per 108 sq. ft.*—

Medium and Heavy Weights, maximum, 11 lb.

Medium and Heavy Weights, passing a No. 65 sieve, maximum, 3 lb.

WORKMANSHIP AND FINISH

Finished Appearance. 8. The surfaces shall be smooth or veined. Deeply ribbed surfaces shall not be acceptable.

Freedom from Defects. 9. The finished product shall be free from visible external defects, such as holes, ragged or untrue edges, breaks, cracks, tears, protuberances and indentations.

Coatings and Surfacing. 10. The coating and mineral surfacing shall be applied uniformly up to the edges of the sheet.

Adhesion of Surfacing. 11. The mineral surfacing shall uniformly cover both sides of the sheet.

Stickiness. 12. The coating and surfacing shall be of such a nature that the finished product will not crack, or be sticky enough to cause tearing or material damage upon being unrolled at atmospheric temperatures above 50° F. (10° C.).

PACKING

Roll-Roofing. 13. The roofing shall be put up in rolls of 108 sq. ft. or 216 sq. ft., as specified in the order. No roll shall contain more than two pieces of roofing, nor shall there be more than 3 per cent of rolls containing two pieces in any shipment. The rolls shall be tightly wound and securely wrapped in a substantial grade of paper. The wrapper shall completely encircle the roll and shall be pasted at the overlap in a manner which will prevent it shifting from position. The ends of the rolls shall be protected with metal caps, cloth or other suitable means. The nails and lap-cement shall be furnished either in each roll or in bulk, as specified in the order. When furnished in bulk, the cloth or metal ends may be omitted. Each roll shall be plainly marked with the manufacturer's name and brand or as agreed upon by the purchaser and seller and shall contain printed directions for laying. Rolls for export shipment shall be packed as agreed upon by the purchaser and seller.

Nails. 14. (*a*) *Nails.*—The gage of the wire shall not be greater than "A. S. & W." No. 10 (0.135 in.) nor thinner than No. 12 (0.105 in.); the head shall not be less than $\frac{3}{8}$ in. in diameter, and not less than 0.025 in. in thickness. The shank shall be between $\frac{3}{4}$ and 1 in. long, with its lower end pointed, and shall be either smooth or barbed, and if the latter, then the barbings shall not increase the diameter of the lower two-thirds more than 0.01 in. The nails shall be zinc coated with not less than $\frac{1}{2}$ oz. nor more than $1\frac{1}{4}$ oz. per sq. ft. of nail surface. Hot-galvanized, electro-galvanized or sherardized coatings will be accepted. There shall be furnished per "square" not less than an average of 252 nails for 36-in., and not less than an average of 275 nails for 32-in. roofing.

Cement.

(*b*) *Lap-cement.*—The cement shall be composed of bituminous materials dissolved in a volatile solvent, and shall be of such a nature as to firmly bind the laps without injurious effect upon the roofing. The cement shall have a minimum flash point of 71° F. (21.5° C.) when tested by the Tagliabue Closed-Cup Tester. There shall be furnished for each square of 36-in. roofing not less than $\frac{3}{4}$ pint and for 32-in. roofing not less than 1 pint. The addition of 5 to 20 per cent by weight of short-fibered asbestos shall be permitted, in which case the quantity of cement shall be increased by $\frac{1}{4}$ pint per "square."

SAMPLING AND TESTING

Sampling and Testing.

15. The material shall be sampled and the properties enumerated in these specifications shall be determined in accordance with the Tentative Methods of Testing Asphalt Roll-Roofing Surfaced with Fine Talc, Granular Talc, or Mineral Granules; also Asphalt Shingles Surfaced with Mineral Granules (A.S.T.M. Designation: D 228 – 33 T) of the American Society for Testing Materials.[1]

INSPECTION

Inspection.

16. Inspection of material shall be made as agreed upon by the purchaser and seller as part of the purchase contract.

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[1] See p. 799.

TENTATIVE SPECIFICATIONS
FOR
ASPHALT ROLL-ROOFING SURFACED WITH POWDERED TALC[1]

A.S.T.M. Designation: D 224 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED AS TENTATIVE, 1925; ADOPTED IN AMENDED FORM, 1927;
REISSUED AS TENTATIVE, 1933.

Scope. 1. These specifications cover smooth-surfaced roll-roofing (medium and heavy weights), either 36 in. or 32 in. in width, composed of roofing felt saturated and coated on both sides with asphalt, and surfaced top and bottom with powdered talc or mica. The medium weight roofing is intended for use on semi-permanent structures and the heavy weight roofing for use on permanent structures.

MANUFACTURE

Manufacture. 2. In the process of manufacture, a single thickness of dry roofing felt shall be impregnated with an asphaltic saturant, then coated on both sides with an asphaltic coating, and finally surfaced on both sides with powdered talc or mica.

Character of Felt. 3. The felt shall be a roofing felt produced by "felting" vegetable and animal fibers. The surface of the felt shall be uniformly smooth, and upon splitting or tearing on the bias, shall appear reasonably free from lumps of underbeaten stock (*i.e.*, stock which has not been beaten or shredded into fiber in the process of manufacture) and particles of foreign substances (*i.e.*, fragments of stone, metal, leather, rubber, straw, wood, etc.).

Character of Saturant and Coatings. 4. The saturant and coatings shall be composed principally of asphaltic materials, and the presence of saponifiable constituents shall be permitted.

Character of Felt after Saturation. 5. The felt shall be thoroughly and uniformly saturated and shall show no unsaturated spots at any point upon cutting 2-in. strips at random across the entire sheet and splitting them open for their full length.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-8 on Bituminous Waterproofing and Roofing Materials, 801 Second Ave., New York City.

These specifications are in effect a revision of the former Standard Specifications for Asphalt Roll-Roofing Surfaced with Powdered Talc (A.S.T.M. Designation: D 224 - 27), which standard was accordingly discontinued in 1933.

Character of Mineral Surfacing.

6. The surfacing shall be non-combustible material such as powdered talc or mica.

PHYSICAL PROPERTIES

Physical Properties.

7. The fabricated product shall conform to the following requirements:

(*a*) *Width of Roll.*—Either 36 or 32 in., as may be specified, ±¼ in.

(*b*) *Area of Roll.*—The average area of the rolls examined shall contain as specified not less than either 108 sq. ft. or 216 sq. ft., which shall be sufficient to cover one or two "squares," respectively.

(*c*) *Weight of Wrapping, Packing, Nails and Cement per "Square."*—Maximum, 4 lb.

NOTE.—Special fixtures may be furnished in lieu of nails and cement, if agreed upon by the purchaser and seller, in which event the above weight may be increased.

(*d*) *Weight of Material per 108 sq. ft. Exclusive of Wrapping, Packing, Loose Mineral Surfacing, Nails and Cement.*—
Medium weight, average, not less than 42 lb., minimum, 40 lb.
Heavy weight, average, not less than 52 lb., minimum, 49 lb.

(*e*) *Pliability at 77° F. (25° C.).*—At least eight strips out of ten shall not crack when bent 90 deg. at a uniform speed over a rounded corner of ½-in. radius.

(*f*) *Behavior on Heating to 176° F. (80° C.) for 2 Hours.*—Volatile matter, maximum, 1.5 per cent. There shall be no flowing, sagging, blistering or absorption of the surface coatings.

(*g*) *Saturant in Moisture-free Felt.*—Medium and heavy weights, minimum, 150 per cent by weight.

(*h*) *Weight of Moisture-free Desaturated Felt per 108 sq. ft.*—
Medium weight, minimum, 10.8 lb. ("Number" 48).
Heavy weight, minimum, 13.5 lb. ("Number" 60).

(*i*) *Ash in Moisture-free Desaturated Felt.*—Maximum, 10 per cent.

(*j*) *Weight of Mineral Surfacings and Mineral Matter in Coatings per 108 sq. ft.*—Medium and heavy weights, maximum, 2 lb.

NOTE.—Should the weight exceed 2 lb. the material shall nevertheless be acceptable, provided the finished weights per 108 sq. ft. are increased by a like amount over the figures specified in Paragraph (*d*).

WORKMANSHIP AND FINISH

8. The surfaces shall be smooth or veined. Deeply ribbed surfaces shall not be acceptable. **Finished Appearance.**

9. The finished product shall be free from visible external defects, such as holes, ragged or untrue edges, breaks, cracks, tears, protuberances and indentations. **Freedom from Defects.**

10. The coating and mineral surfacing shall be applied uniformly up to the edges of the sheet. **Coatings and Surfacing.**

11. The mineral surfacing shall uniformly cover both sides of the sheet. **Adhesion of Surfacing.**

12. The coating and surfacing shall be of such a nature that the finished product will not crack, or be sticky enough to cause tearing or material damage, upon being unrolled at atmospheric temperatures above 50° F. (10° C.). **Stickiness.**

PACKING

13. The roofing shall be put up in rolls of 108 sq. ft. or 216 sq. ft. as specified in the order. No roll shall contain more than two pieces of roofing, nor shall there be more than 3 per cent of rolls containing two pieces in any shipment. The rolls shall be tightly wound and securely wrapped in a substantial grade of paper. The wrapper shall completely encircle the roll and shall be pasted at the overlap in a manner which will prevent it shifting from position. The ends of the rolls shall be protected with metal caps, cloth or other suitable means. The nails and lap-cement shall be furnished either in each roll, or in bulk as specified in the order. When furnished in bulk, the cloth or metal ends may be omitted. Each roll shall be plainly marked with the manufacturer's name and brand or as agreed upon by the purchaser and seller and shall contain printed directions for laying. Rolls for export shipment shall be packed as agreed upon by the purchaser and seller. **Roll-Roofing.**

14. (*a*) *Nails.*—The gage of the wire shall not be greater than "A. S. & W." No. 10 (0.135 in.) nor thinner than No. 12 (0.105 in.); the head shall not be less than $\frac{3}{8}$ in. in diameter, and not less than 0.025 in. in thickness; the shank shall be between $\frac{3}{4}$ and 1 in. long, with its lower end pointed, and shall be either smooth or barbed, and if the latter, then the barbings shall not increase the diameter of the lower two-thirds more than 0.01 in. The nails shall be zinc coated with not less than $\frac{1}{2}$ oz. nor more than $1\frac{1}{4}$ oz. per sq. ft. of nail surface. Hot-galvanized, electrogalvanized, or sherardized coatings will be accepted. There shall be furnished per "square" not less than an average of 252 nails for 36-in., and not less than an average of 275 nails for 32-in. roofing. **Nails.**

Cement.

(*b*) *Lap-cement.*—The cement shall be composed of bituminous materials dissolved in a volatile solvent, and shall be of such a nature as to firmly bind the laps without injurious effect upon the roofing. The cement shall have a minimum flash point of 71° F. (21.5° C.) when tested by the Tagliabue Closed-Cup Tester. There shall be furnished for each square of 36-in. roofing not less than $\frac{3}{4}$ pint and for 32-in. roofing not less than 1 pint. The addition of 5 to 20 per cent by weight of short-fibered asbestos shall be permitted, in which case the quantity of cement shall be increased by $\frac{1}{2}$ pint per "square."

SAMPLING AND TESTING

Sampling and Testing.

15. The material shall be sampled and the properties enumerated in these specifications shall be determined in accordance with the Tentative Methods of Testing Asphalt Roll-Roofing Surfaced with Fine Talc, Granular Talc, or Mineral Granules; also Asphalt Shingles Surfaced with Mineral Granules (A.S.T.M. Designation: D 228 – 33 T) of the American Society for Testing Materials.[1]

INSPECTION

Inspection.

16. Inspection of material shall be made as agreed upon by the purchaser and seller as part of the purchase contract.

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[1] See p. 799.

TENTATIVE METHODS OF TESTING ASPHALT ROLL-ROOFING SURFACED WITH FINE TALC, GRANULAR TALC, OR MINERAL GRANULES; ALSO ASPHALT SHINGLES SURFACED WITH MINERAL GRANULES[1]

A.S.T.M. Designation: D 228 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED AS TENTATIVE, 1925; ADOPTED, 1927; REISSUED AS TENTATIVE, 1930; REVISED, 1931, 1933.

Scope.

1. These methods cover the examination of roofings and shingles composed of roofing-felt, saturated and coated on both sides with asphalt, and surfaced on the top with either powdered or granulated mineral matter, and on the under side with powdered mineral matter.

2. Asphalt roll-roofings and shingles may be divided into two types, as follows (see Fig. 1):

Types of Roofing and Shingles.

Type X.—A layer of felt saturated and coated with bituminous matter having the surface coatings dusted with fine mineral matter (for example, talc). This type embraces what is commercially known as "smooth-surfaced roll-roofing."

Type Y.—This type is similar to Type X, but with a top surfacing of either (1) coarse mineral matter (for example, granular slate) embracing what is commercially known as "mineral-surfaced roll-roofing" and "mineral-surfaced shingles;" or (2) moderately coarse mineral matter (for example, granular talc) embracing what is commercially known as "roll-roofing surfaced with granular talc."

SAMPLING

Sampling.

3. From each shipment or portion thereof representing a product of the same kind, class, and weight, a number of rolls or bundles shall be selected at random, equivalent to one-half the cube root of the total number of rolls or bundles included in the lot, except that in lots of 1000 or less, five rolls or bundles shall be taken. If the cube root, as calculated, proves to be a fractional number, it shall be expressed as the nearest higher whole number. For convenience, the following

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-8 on Bituminous Waterproofing and Roofing Materials, 801 Second Ave., New York City.

These methods are in effect a revision of the former Standard Methods of Testing Asphalt Roll-Roofing Surfaced with Fine Talc, Granular Talc, or Mineral Granules; also Asphalt Shingles Surfaced with Mineral Granules (A.S.T.M. Designation: D 228 - 27), which standard was accordingly discontinued in 1930.

table is given, showing the number of samples to be selected from shipments of various sizes:

PACKAGES IN SHIPMENT	NUMBER OF PACKAGES SELECTED	PACKAGES IN SHIPMENT	NUMBER OF PACKAGES SELECTED
Up to 1000	5	5 833 to 8 000	10
1001 to 1728	6	8 001 to 10 648	11
1729 to 2744	7	10 649 to 13 824	12
2745 to 4096	8	13 825 to 17 576	13
4097 to 5832	9	17 577 to 21 952	14

DETERMINATION OF SIZE AND WEIGHT

(*A*) *Smooth-roll and Mineral-Surfaced Roll-Roofing*

Packing Material, Nails and Cement. 4. Each roll selected shall be weighed to the nearest $\frac{1}{4}$ lb. The wrappers, packing material, nails, and cement from each roll shall be weighed together to the nearest $\frac{1}{4}$ lb. and the average weight thereof per "square" shall be recorded. The quantity and character of nails and cement shall be recorded.

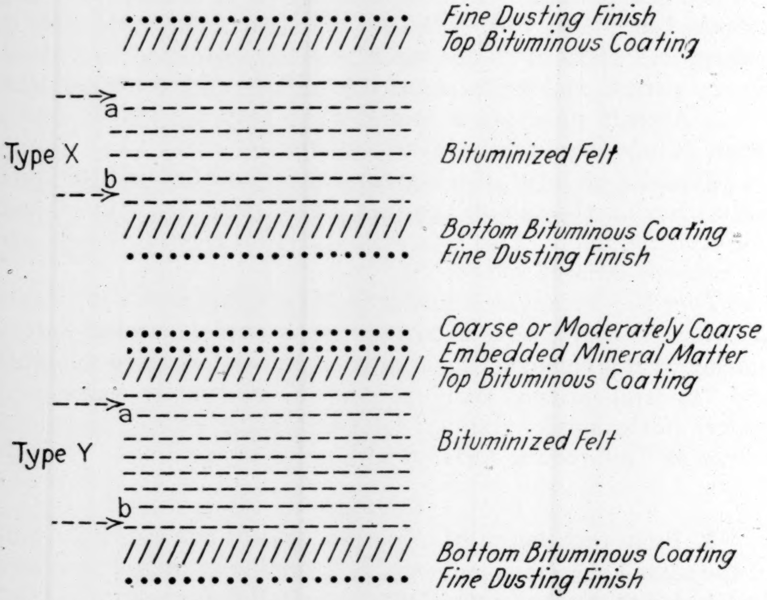
Fine Dusting Finish
Top Bituminous Coating
a
Type X
Bituminized Felt
b
Bottom Bituminous Coating
Fine Dusting Finish
Coarse or Moderately Coarse
Embedded Mineral Matter
Top Bituminous Coating
a
Type Y
Bituminized Felt
b
Bottom Bituminous Coating
Fine Dusting Finish

FIG. 1.—Construction of Two Types of Asphalt Roll-Roofing and Shingles.

Weight of Loose Surfacing. 5. Each roll shall be unwound and the workmanship and finish of the roofing observed. Record the weight of any loose surfacing that may fall off in so doing.

Area. 6. The length and width of each roll shall be measured to the nearest $\frac{1}{4}$-in., and the square feet of material contained in each roll shall be calculated. From these values, the average area of the rolls examined shall be calculated.

Minimum Weight per 108 sq. ft.

7. From the above the net weight, exclusive of loose surfacing, of roofing per 108 sq. ft. contained in each roll shall be calculated and the minimum weight per 108 sq. ft. recorded. This shall be regarded as the minimum weight per 108 sq. ft. of the lot.

Average Weight per 108 sq. ft.

8. The average weight per 108 sq. ft. for the rolls examined shall be calculated. This shall be regarded as the average weight per 108 sq. ft. of the lot.

Selecting Average Weight Rolls.

9. From the rolls examined, the one whose weight per 108 sq. ft. is nearest the average weight of the lot shall be selected. The first convolution or two shall be unrolled, and with a knife and straight edge, the sheet shall be cut across at right angles to the edges. A section measuring exactly 30-in. in the direction of the roll's length shall then be removed. The width of this section shall be measured to the nearest $\frac{1}{32}$-in. and weighed, neglecting any loose surfacing. The weight in pounds per 108 sq. ft. shall then be calculated from the following formula:

$$\text{Pounds per 108 sq. ft.} = \frac{\text{Weight of 30-in. section in ounces}}{\text{Width of 30-in. section in inches}} \times 32.4$$

The weight so determined shall check within 1.5 per cent, the average weight per 108 sq. ft. of the lot (Section 8). If this sample fails to check, then additional samples shall be cut from the same roll, until one is obtained which does and this sample shall be kept for further examination as described in Sections 19 to 25.

NOTE.—As a referee method, or in case any dispute arises regarding the properties as may be ascertained from the particular sample selected, a 30-in. sample shall be taken and examined separately from each roll sampled in Section 3.

(*B*) *Shingles Surfaced with Mineral Granules*

Weight of Packing Material.

10. Each bundle selected shall be weighed to the nearest $\frac{1}{4}$ lb. The packing materials shall be weighed to the nearest $\frac{1}{4}$ lb. and the weight recorded separately for each bundle. The average weight of packing material per "square" shall be recorded.

Weight of Loose Surfacing.

11. The shingles in each bundle, *a*, shall be counted and the workmanship and finish of the shingles shall be observed. Record the weight of any loose surfacing that may fall off in so doing.

Net Weight and Area.

12. From the above the net weight of each bundle, exclusive of loose surfacing, shall be calculated, *b*. The dimensions of two representative shingles shall be accurately measured and the net area of material in each shingle calculated in square feet, *c*.

Minimum Weight per 108 sq. ft.

13. The area in square feet of material contained in each bundle ($a \times c$) shall be calculated. The net weight of roofing material per 108 sq. ft. contained in each bundle $\left(\frac{b}{a \times c} \times 108\right)$ shall be calculated, and the minimum weight per 108 sq. ft. recorded. This shall be regarded as the minimum weight per 108 sq. ft. of the lot.

Average Weight per 108 sq. ft.

14. The average weight, d, per 108 sq. ft. for the bundles examined shall be calculated. This shall be regarded as the average weight per 108 sq. ft. of the entire shipment.

The average weight per shingle $\left(\frac{c \times d}{108}\right)$ shall be calculated.

Selecting Average Weight Shingles.

15. From the bundles selected, a definite number of representative shingles whose weight per 108 sq. ft. shall fall within 1.5 per cent of the average weight ascertained in Section 14 shall be taken for further examination in accordance with Sections 19 to 25. The number of shingles so selected shall represent as closely as possible 6 sq. ft. of material, and shall be selected as far as possible from different bundles.

NOTE.—As a referee method, or in case any dispute arises regarding the properties as may be ascertained from the particular sample selected, then a similar sample shall be taken from each bundle of shingles selected in accordance with Section 3 and examined separately.

DETERMINATION OF PLIABILITY OF SMOOTH ROLL-ROOFING AND MINERAL-SURFACED ROLL-ROOFING

Pliability.

16. With a photographic trimmer, ten strips shall be cut from a sample of roofing, each 1 in. in width and 8 in. in length, five strips in the direction of the fiber grain, and five across the grain. These strips shall be immersed in water at 77° F. (25° C.) for 10 to 15 minutes, after which they shall be removed from the water and immediately bent through an angle of 90 deg. over a rounded corner of ½ in. radius in exactly two seconds without exerting any strain upon the test strip other than that required to keep it in contact with the rounded corner and to avoid kinking.

A block of wood 3 in. square by 2 in. thick with rounded corners of the dimension specified shall be used in making this test.

The strips of roofing, exposure side up, shall be held by hand tight against the upper 2-in. face of the block. The projecting end of the strip shall then be bent over the rounded corner of specified radius with the other hand.

Surface ruptures aggregating more than ⅛ in. in length in any direction shall be considered a crack.

DETERMINATION OF BEHAVIOR ON HEATING

Behavior on Heating.

17. Two strips shall be cut from the sample of roofing or shingles, each approximately 8 by 8 in. They shall be weighed and then suspended vertically, in the same direction as the material would be applied to the roof, in the center of an air-oven maintained at 176° F. ± 5° F. (80° C. ± 3° C.) by means of a thin wire fastened through holes punctured near one edge. The internal dimensions of the oven shall not be less than 12 by 12 by 12-in. An electrically-heated oven is recommended. The thermometer shall be inserted in the oven to such a depth that its bulb will be in line with the center of the specimens. The strips shall be maintained at the prescribed temperature for exactly two hours, then cooled, in a desiccator, and each specimen weighed. The average loss shall be calculated as a percentage. Any change in appearance of the specimen shall be recorded, such as flowing, sagging, blistering, or absorption of the coatings; also sliding of granular surfacing.

SEPARATION OF THE ROOFING OR SHINGLES INTO THEIR COMPONENT PARTS

Composition.

18. The mineral matter, bituminous matter and fibrous matter may be distributed in the following manner:

A. Mineral Matter

I. Detached............. II. Embedded in the top coating............. III. Embedded in the bottom coating.............	*Fine Mineral Matter* (for example, finely ground talc or mica), Type X (on top and bottom); also Type Y (on bottom only). *Moderately Coarse Mineral Matter* (for example, coarsely ground talc), Type Y (on top only). *Coarse Mineral Matter* (for example, crushed slate, crushed brick or tile) Type Y (on top only).
IV. Admixed with the top coating (Types X and Y)................. V. Admixed with the bottom coating (Types X and Y).............	May or may not be present. If present, consists of very fine mineral matter (for example, clay, silica, limestone, slate flour, shale, etc.).

VI. Ash present in desaturated felt (that is, ash on incineration).

B. Bituminous Matter

I—Contained in the top coating.
II—Contained in the bottom coating.
III—Saturant of the felt.

C. Fibrous Matter

I—The desaturated felt.

Test Strips for Separation of Roofing and Shingles.

19. The test strips for the separation of prepared roofing and shingles into their component parts shall be prepared as follows:

From the samples representing the average weight obtained in Sections 9 and 15 a number of strips shall be cut, each measuring approximately 2-in. in width by 8 in. in length. These shall be weighed, the length and width measured to within 1 mm. or $\frac{1}{32}$ in., and the weight calculated per 108 sq. ft. Any of the 2 by 8-in. strips whose weight varies more than 1.5 per cent from the average weight of the shipment as determined in Sections 8 and 14, shall be rejected, and the remaining strips shall be retained for further examination.

NOTE.—If a strip is cut to exactly 2 by 7.46 in. its weight in grams divided by two gives directly the weight in pounds per 108 sq. ft.

Bituminous Saturation (B-III) in Moisture-Free Felt.

20. (*a*) From the 2 by 8-in. strips, cut 40 strips about $\frac{3}{4}$ by 2 in. and weigh, this being a convenient size to handle. These strips shall then be separated into three horizontal sections. The small arrows *a* and *b*, to the left of the various types of roofing illustrated in Fig. 1, indicate approximately where the layers should be separated. The top bituminous coating, with the embedded mineral matter, shall be removed first.

NOTE.—The purpose shall be to remove the entire coatings with some of the saturated felt adhering and no coatings left on the central section of saturated felt. The operator may accomplish this in any way that is most convenient. Care shall be taken to preserve the mineral surfacing with the layers to which it belongs if it becomes detached during the operation.

(*b*) These three horizontal sections thus obtained shall be weighed separately and the total weight should agree within 1 per cent with the original weight of the strips which have been separated. The saturated felt (middle section) shall be extracted with benzol (boiling point 80 to 82° C.) or c.p. carbon disulfide, in a suitable extractor or centrifuge and the extraction continued until the washings have become colorless. The desaturated felt shall be removed from the extractor, placed in a tared weighing bottle provided with a ground-glass stopper, heated in a ventilated oven at 225° F. ± 5° F. (107° C. ± 3° C.) for 30 minutes, the stopper inserted, then cooled and weighed. The heating shall be repeated until the weight of the felt remains constant as determined by two consecutive weighings taken with an intervening heating period of not less than 10 minutes, which shall show a further loss in weight of not more than 0.1 per cent. Calculate the weight of bituminous saturation by difference. The saturant may be recovered by combining the extract and washings in a 200-ml. distilling flask, provided with a dropping funnel to add the solution during distillation, to which is attached a water-cooled condenser and a receiver, the latter having a vented connection to a vacuum pump. The distilling bulb is immersed in a bath having a temperature of about 212° F. (100° C.) if the solvent were carbon disulfide and a temperature of about 275° F. (135° C.) if benzol or chloroform were used as the solvent. Distillation shall be continued at this temperature at atmospheric pressure until no more solvent is evolved, after which vacuum shall be applied very gradually until a vacuum of 0.5 in. mercury pressure is attained. Great care shall be exercised in applying the vacuum gradually to prevent foaming. This vacuum shall be continued for one hour after the specified vacuum has been reached. The distilling flask shall then be disconnected and the residue represents the felt saturant and shall be weighed.

NOTE.—Use the residue of bituminous saturation recovered from the felt for examining its physical and chemical characteristics.

(*c*) Calculate the percentage of bituminous saturation (*B*–III) carried by the dry felt.

(*d*) Calculate the weight in pounds per 108 sq. ft. of bituminous saturation (*B*–III) present in the dry felt, that is, the weight of moisture-free felt multiplied by the percentage of bituminous saturation (Section 22 and Paragraph (*c*) of this section).

Ash in Moisture-Free Felt (A-VI).

21. The desaturated felt obtained as described in Section 22 shall be cut into squares about 2 cm. on each side and thoroughly mixed. Pieces amounting to about 10 g. shall be taken at random and dried at 225° F. (107° C.) for 30 minutes. They shall be cooled in a desiccator, accurately weighed and then incinerated in a weighed crucible either over an open flame or in a muffle until all the carbon has been consumed, and weighed. The percentage of ash shall be calculated on the basis of the moisture-free felt.

NOTE.—The desaturated felt may be examined to determine the percentage of various fibers contained therein by the Tentative Methods of Analysis of Roofing Felt for Fiber Composition (A.S.T.M. Designation: D 272 - 29 T) of the American Society for Testing Materials.[1]

Moisture-Free Felt (C-I).

22. The top and bottom horizontal sections separated from the roofing strips as described in Section 20 shall now be extracted separately with benzol (boiling point 80 to 82° C.) or c.p. carbon disulfide in a suitable extractor or centrifuge and the extraction continued until the washings have become colorless. The insoluble residue from each extraction shall be removed and the pieces of felt picked out and brushed free of adhering mineral matter. The clean pieces of felt shall be placed in a tared weighing bottle, heated until

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 724 (1929); also 1933 Book of A.S.T.M. Tentative Standards, p. 697.

free from moisture and weighed as described in Section 20. Calculate the percentage of felt in the roofing from the combined weights obtained in the top and bottom sections and in the middle section obtained under Section 20. From the weight so obtained and the total area of the strips of original desaturated felt (area of strips taken for test under Section 20) compute the weight of moisture-free felt in pounds per 108 sq. ft. by one of the following formulas:

$$\text{Pounds per 108 sq. ft.} = \frac{\text{Weight of felt in grams}}{\text{Area in square centimeters}} \times 221.2$$

or

$$\text{Pounds per 108 sq. ft.} = \frac{\text{Weight of felt in grams}}{\text{Area in square inches}} \times 34.3$$

Bituminous Matter in the Top and Bottom Coatings, Respectively (B-I and B-II).

23. (*a*) The admixed and embedded mineral matter separated from the felt of each extraction made under Section 22 shall be dried at 225° F. ± 5° F. (107° C. ± 3° C.) cooled in a desiccator and weighed. Calculate the weight of bituminous saturant (*B*–III) present in the felt contaminating these top and bottom sections, that is, the felt recovered on extraction multiplied by the percentage of bituminous saturation (Section 20 (*c*)). From the original weight of the top and bottom sections, respectively, subtract the combined weights of dry felt, bituminous saturant and embedded and admixed mineral matter. The difference represents the weight of bituminous matter in the surface coating of that particular section.

(*b*) Calculate the weight in pounds per 108 sq. ft. of bituminous matter (B–I) in the top coating.

(*c*) Calculate the weight in pounds per 108 sq. ft. of bituminous matter (B–II) in the bottom coating.

(*d*) Calculate the weight in pounds per 108 sq. ft. of total mineral matter embedded and admixed with the top coating.

(*e*) Calculate the weight in pounds per 108 sq. ft. of total mineral matter embedded and admixed with bottom coating.

(*f*) To separate the bituminous constituents in the coatings for further examination and also to check the percentage of mineral matter, both detached and embedded in the top and bottom coatings, with that determined above, the detached mineral matter shall be brushed off from six weighed 2 by 8-in. strips. The strips shall again be weighed and the percentage calculated based on the original weight of strips. The outer portion of the top and bottom surface coatings, respectively, shall then be scraped off after the strips have been heated in an oven at 212° F. (100° C.) for 30 minutes. The coatings shall be scraped off by holding a dull knife at right angles to the strip of roofing supported on a firm level surface and drawing the blade sideways under moderate pressure. Care shall be taken to avoid scraping entirely through the surface coating. This is important. The scrapings shall then be weighed and dissolved in benzol (boiling point 80 to 82° C.) or c.p. carbon disulfide; and the mineral matter separated by filtering or centrifuging and washing with successive portions of solvent. The mineral matter shall then be dried at 225° F. (107° C.), cooled in a desiccator and weighed. Calculate the percentage of mineral matter based on the original weight of roofing strips taken, which should check with that obtained previously. The bituminous matter in the scrapings shall be calculated by difference and reduced to a percentage basis on the original roofing strips used. The bituminous coating shall be recovered by evaporating off the solvent as described under Section 20. Both surface coatings should be treated separately in this manner.

NOTE.—Use the separated bituminous coatings for examining their physical and chemical characteristics.

Coarse and Fine Admixed Mineral Matter.

24. (*a*) *Coarse or Moderately Coarse Embedded Mineral Matter* (*A–II*), *also Fine Admixed Mineral Matter* (*A–IV*) *in the Top Coating of Type Y.*—The mineral matter recovered from the top sections of Type Y in Section 20 shall be boiled with 100 ml. water and washed through a 65-mesh copper wire screen with sufficient water to remove the fine mineral matter. The total aqueous suspension of mineral matter which passes through the screen shall then be recovered by filtering the washings through a weighed Gooch crucible, then dried at 225° F. (107° C.) and reweighed. This approximately represents the fine mineral matter admixed with the top coating. The mineral constituents retained on the 65-mesh screen represent approximately the coarse or moderately coarse mineral matter embedded in the top coating. This shall likewise be dried and weighed.

(*b*) Calculate the weight in pounds per 108 sq. ft. of coarse or moderately coarse mineral matter (*A*–II) embedded in the top coating of Type Y.

(*c*) Calculate the weight in pounds per 108 sq. ft. of fine mineral matter (*A*–IV) admixed with the top coating of Type Y.

Fine Embedded and Admixed Mineral Matter.

25. *Fine Embedded and Admixed Mineral Matter* (*A*–II *and A–IV*) *in the Top Coating of Type X. Likewise Fine Embedded and Admixed Mineral Matter* (*A–III and A–IV*) *in the Bottom Coating of Types X and Y.*—From the data obtained in Sections 23 and 24, calculate the following:

(*a*) The percentage by weight of fine mineral matter admixed with the top coating (Type X);

(*b*) The percentage by weight of fine mineral matter admixed with the bottom coating (Types X and Y);

(*c*) The weight in pounds per 108 sq. ft. of fine mineral matter admixed with the top coating (Type X), that is, the weight of bituminous matter in the top coating multiplied by the percentage by weight of fine mineral matter admixed with the top coating (Sections 23 (*b*) and 25 (*a*)).

(*d*) The weight in pounds per 108 sq. ft. of fine mineral matter admixed with the bottom coating (Types X and Y), that is, the weight of bituminous matter in the bottom coating multiplied by the percentage by weight of fine mineral matter admixed with the bottom coating (Sections 23 (*c*) and 25 (*b*)).

(*e*) The weight in pounds per 108 sq. ft. of fine mineral matter embedded in the top coating (Type X) (Section 23 (*d*)).

(*f*) The weight in pounds per 108 sq. ft. of fine mineral matter embedded in the bottom coating (Types X and Y), that is, the weight of total mineral matter embedded and admixed with the bottom coating minus the weight of fine mineral matter admixed with the bottom coating (Sections 23 (*e*) and 25 (*d*)).

REPORT

Compilation of Results.

26. The following items shall be reported in pounds per 108 sq. ft.:

Items	Type X	Type Y
MINERAL MATTER:		
Fine mineral matter embedded in top coating	Section 25 (*e*)	....
Coarse or moderately coarse mineral matter embedded in top coating	....	Section 24 (*b*)
Fine mineral matter embedded in bottom coating	Section 25 (*f*)	Section 25 (*f*)
Fine mineral matter admixed with top coating	Section 25 (*c*)	Section 24 (*c*)
Fine mineral matter admixed with bottom coating	Section 25 (*d*)	Section 25 (*d*)
BITUMINOUS MATTER:		
Contained in top coating	Section 23 (*b*)	Section 23 (*b*)
Contained in bottom coating	Section 23 (*c*)	Section 23 (*c*)
Saturant of the felt	Section 20	Section 20
FIBROUS MATTER:		
Felt after desaturation	Section 22	Section 22
Net weight of roofing material	Sum	Sum
Average weight per 108 sq. ft. (check total)	Section 8, 9 or 14	Section 8, 9 or 14
Loose mineral surfacing	Section 6 or 11	Section 6 or 11
Packing material, nails and cement	Section 4	Section 3 or 9
Gross weight per 108 sq. ft	Sum	Sum
ASH:		
Percentage from desaturated felt	Section 21	Section 21

If desired, the results may also be expressed as a percentage by weight.

TENTATIVE SPECIFICATIONS

FOR

BLACK BIAS-CUT VARNISHED CLOTH TAPE USED FOR ELECTRICAL INSULATION[1]

A.S.T.M. Designation: D 373 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1933.

Scope

1. These specifications cover black seamless and sewed-seam bias-cut varnished cloth tapes 7 to 12 mils in thickness to be used for insulating bus bars, joints and terminals of electric wires and cables, and other electrical apparatus connections.

NOTE.—Orders for material under these specifications shall include the following information:

The desired nominal thickness, width and length (Sections 7, 8 and 9);
Whether seamless or sewed-seam tapes are desired (Sections 4 and 5);
Type of packing, dry or oil (Sections 17, 18 and 19);
Number of rolls in package (Sections 18 and 19); and
Marking on package (Section 20).

MANUFACTURE

Cloth and Varnish

2. The cloth and the number of coats of varnish applied shall be such as to produce a product which will meet the requirements of these specifications.

Defects

3. In general, the tape shall be free from wrinkles, excessive pebbling, blisters, and other imperfections.

Splices

4. Splices are those joints made by the manufacturer of the untreated cloth. In the case of seamless bias-cut tapes, splices shall not occur more than once in each roll, except that rolls having a length of 6 yd. or less shall contain no splices.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. J. A. Scott, Secretary of Committee D-9 on Electrical Insulating Materials, General Electric Co., Schenectady, N. Y.

Seams

5. Seams are those joints made during or subsequent to the varnish treatment of the cloth. In the case of sewed-seam bias-cut tapes, seams shall not occur more than once in each 45 in. of length.

METHODS OF TESTING

Methods of Testing

6. (*a*) Varnished cloth tape shall be sampled, conditioned and tested in accordance with the Tentative Methods of Testing Varnished Cloths and Varnished Cloth Tapes Used in Electrical Insulation (A.S.T.M. Designation: D 295 – **33** T) of the American Society for Testing Materials.[1]

(*b*) All specimens taken from a single roll shall be numbered or marked so that failures can be identified with the roll.

DIMENSIONS AND PERMISSIBLE VARIATIONS

Thickness

7. The nominal thickness shall be specified in the purchase order. The average thickness shall be determined from the ten measurements taken on a specimen before testing in accordance with Section 14, the five measurements on the specimen as in Section 15, and the other five measurements on the specimen as in Section 16. The average thickness shall not vary more than ± 12 per cent from the specified nominal thickness and no individual measurement shall vary by more than 20 per cent from the specified nominal thickness.

Width

8. The nominal width shall be specified in the purchase order. Individual measurements on all the samples selected under Section 6 shall not vary more than $\pm\frac{1}{32}$ in. from the specified nominal width for tapes 1 in. or less in width, nor more than $\pm\frac{1}{16}$ in. for tapes over 1 in. in width.

Length

9. The nominal length or yards per roll shall be specified in the purchase order. The measured lengths of individual rolls selected under Section 6 shall be not less than that specified.

PHYSICAL PROPERTIES AND TESTS

Flexibility

10. The varnish coating shall be flexible and shall not crack when the tape is doubled upon itself and creased between the thumb and index finger.

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[1] See p. 864.

Tensile Breaking Strength

11. (*a*) The tensile breaking strength requirement varies with the nominal thickness of the tape. Let t represent the nominal thickness in mils; then, the average tensile breaking strength of the specimens should be not less than $35 + (t-7)$ lb. per inch of width. If the first specimen from a roll does not conform to this requirement, tests of two additional specimens from the same roll shall be made. Then the average of the three tests shall conform to the above requirements. The tensile breaking strength of any of the tests made shall be not less than $29 + (t-7)$ lb. per inch of width.

(*b*) The tensile breaking strength of the "jointed selvages," in the case of seamless bias-cut tapes, shall not be less than 80 per cent of the values specified in Paragraph (*a*).

(*c*) The tensile breaking strength of the "seams," in the case of sewed-seam bias-cut tapes, shall not be less than 60 per cent of the values specified in Paragraph (*a*).

Elongation

12. The elongation of one specimen from each of the selected rolls shall be measured at a temperature T between 20 and 30 C. and shall be not less than that specified in the following table:

NOMINAL THICKNESS	LOAD, LB. PER INCH OF TAPE WIDTH	ELONGATION, PER CENT
7 mils	5	$1.7 + (T-20) \times 0.1$
Over 7 mils	6	$1.7 + (T-20) \times 0.1$

Resistance to Oil

13. One specimen from each of the selected rolls shall be subjected to test for resistance to oil described in the test methods referred to in Section 6. The oil used shall be an insulating oil having a flash point of not less than 135 C. (275 F.), as determined by the Cleveland open cup in accordance with the Standard Method of Test for Flash and Fire Points by Means of Open Cup (A.S.T.M. Designation: D 92) of the American Society for Testing Materials.[1] The varnished film shall show no evidence of disintegration in the oil nor flake either in the oil or on the blotter used in the test.

Dielectric Strength, as Received

14. (*a*) Ten punctures shall be made on one specimen from each roll as received. The dielectric strength values are the puncturing values in volts divided by the average thickness (Section 7) in mils. The average of the ten dielectric strength values for each roll as

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[1] 1933 Book of A.S.T.M. Standards, Part II, p. 800.

received, *l*, shall conform to the requirements shown in Table I. The dielectric strength values when analyzed to determine the uniformity of the material shall conform to the requirements of Paragraphs (*b*) and (*c*).

(*b*) *Uniformity Within the Roll.*—The deviation factor for each roll shall be not more than 0.11 when calculated from the following formula:

$$\text{Deviation factor of roll} = \frac{h - l}{h + l}$$

where h = the average of the five highest dielectric strength values of the roll, in volts per mil; and

l = the average of the five lowest dielectric strength values of the roll, in volts per mil.

(*c*) *Uniformity of the Shipment.*—The deviation factor for each shipment shall be not more than 0.10 when calculated from the following formula:

$$\text{Deviation factor of shipment} = \frac{a - l}{a + l}$$

where a = the average dielectric strength of the entire shipment, in volts per mil; and

l = the average of the five lowest dielectric strength values of the roll, in volts per mil.

TABLE I.—DIELECTRIC STRENGTH REQUIREMENTS FOR VARNISHED CLOTH TAPE.

NOMINAL THICKNESS	DIELECTRIC STRENGTH, MINIMUM AVERAGE VOLTS PER MIL		
	AS RECEIVED, *l*	AFTER ELONGATION	AFTER HOT OIL
Over 10 mils..............	1100	1000	950
9 and 10 mils, incl..........	1000	900	850
Under 9 mils..............	900	800	750

Dielectric Strength, After Elongation

15. Five punctures shall be made inside the gage length on each specimen after the elongation test specified in Section 12. The average of the five dielectric strength values for each roll shall conform to the requirements shown in Table I.

Dielectric Strength, After Hot Oil

16. Five punctures shall be made on each specimen after the test for resistance to oil specified in Section 13. The average of the five dielectric strength values for each roll shall conform to the requirements shown in Table I.

PACKING AND MARKING

Packing

17. The purchaser shall specify whether tape is to be supplied dry or immersed in oil.

Dry Packing

18. In the case of dry tape, the purchaser shall specify the number of rolls per package and whether each roll shall be dipped or whether each package shall be dipped in a moisture-resistant wax or neither or both. The wrapping shall be secure and shall protect the contents.

Packing in Oil

19. Oil-immersed tape shall be supplied in suitable oil-tight cans with easily removable lids. The purchaser shall specify the number, width, and length of rolls and the type of oil to be supplied in each can.

Marking

20. The purchaser shall specify the marking desired on each package or can; unless the marking is definitely specified, the package shall conform with the usual trade customs.

INSPECTION AND REJECTION

Inspection and Testing

21. The material shall be inspected and tested within three weeks of its receipt by the purchaser.

Rejection

22. (*a*) The purchaser reserves the right to reject any part of the shipment that does not conform to the requirements for packing and marking as specified in Sections 18, 19 and 20.

(*b*) The failure of a sample roll to conform to the requirements of one or more of the sections enumerated under Paragraphs (*c*) and (*d*) shall be counted as only one roll failure.

(*c*) The failure of 35 per cent or more of the sampled rolls to conform to the requirements of Sections 3, 4, 5, 7, 8, 9 and 10 shall constitute cause for rejection of the entire shipment without further tests.

(*d*) The failure of 50 per cent or more of the sampled rolls to conform to the requirements of Sections 11, 12, 13, 14, 15 and 16 shall constitute cause for rejection of the entire shipment.

NOTE.—The following illustrates a convenient method of recording failures of sampled rolls:

ROLL NO.	FAILURES UNDER SECTIONS							ROLL FAILURES
	3	4	5	7	8	9	10	
1				X				X
2				X	X			X
3								
4								
5								
6					X	X	X	X
7								
8								
9								
10								
Total rolls sampled = 10								Total failures = 3 rolls

Thirty per cent of the rolls failed; therefore, this shipment passes Paragraph (*c*).

Claims

23. Rejection claims shall be made to the seller in writing within four weeks of receipt of material by the purchaser. The results of tests made by the purchaser on which rejection is based shall be furnished to the seller, who shall, within one week of receipt of all such claims, either agree to satisfy the claim or send a representative to the plant of the purchaser to resample the shipment. Samples so selected shall be sealed and submitted to an umpire, mutually agreeable to the purchaser and seller, whose decision should be final.

Settlement of Claims

24. The expense of the umpire tests shall be paid by the loser. In the case of rejection being established, the seller shall pay the freight both ways on the rejected material.

TENTATIVE SPECIFICATIONS

FOR

FLEXIBLE VARNISHED TUBING USED IN ELECTRICAL INSULATION[1]

A.S.T.M. Designation: D 372 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

Issued, 1933.

Scope

1. These specifications cover three grades of flexible varnished tubing which are used as electrical insulation for leads on electrical apparatus, as follows:

Grade A.—Tubing generally known as "flexible varnished tubing," or "motor and transformer tubing," or "impregnated magneto tubing;"

Grade B.—Tubing generally known as "radio spaghetti;" and

Grade C.—Tubing generally known as "non-flammable tubing," or "flame-resistant tubing."

Material

2. (*a*) The base material of the tubing shall be good quality braided cotton sleeving.

(*b*) The cotton sleeving shall be uniformly coated with varnish, and the finished tubing shall be reasonably free from defects such as pimples, blisters, wrinkles, cracks, and similar imperfections.

Color

3. The color desired shall be specified by the purchaser.

Dimensions

4. The inside diameters of flexible varnished tubing shall conform to the following requirements:

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[1] **Criticisms of these Tentative Specifications are solicited and should be directed to Mr. J. A. Scott, Secretary of Committee D-9 on Electrical Insulating Materials, General Electric Co., Schenectady, N. Y.**

SIZE	INSIDE DIAMETER, IN.			SIZE	INSIDE DIAMETER, IN.		
	MAXIMUM	MINIMUM	NOMINAL		MAXIMUM	MINIMUM	NOMINAL
1	0.299	0.289	0.294	10	0.110	0.102	0.106
2	0.268	0.258	0.263	11	0.099	0.091	0.095
3	0.239	0.229	0.234	12	0.089	0.081	0.085
4	0.212	0.204	0.208	13	0.080	0.072	0.076
5	0.190	0.182	0.186	14	0.068	0.064	0.066
6	0.170	0.162	0.166	15	0.061	0.057	0.059
7	0.152	0.144	0.148	16	0.055	0.051	0.053
8	0.137	0.129	0.133	17	0.049	0.045	0.047
9	0.122	0.114	0.118	18	0.044	0.040	0.042

NOTE.—For the millimeter sizes of foreign-made tubing and for odd sizes not contained in the above table, the nominal inside diameter shall be 0.004 in. (0.1016 mm.) larger than the gage size it is intended to cover for all sizes between the limits of 0.076 in. (1.93 mm.) and 0.208 in. (5.28 mm.) and shall be subject to a permissible variation of ±0.004 in. (0.1016 mm.). For sizes larger than 0.208 in. (5.28 mm.), the nominal inside diameter shall be 0.005 in. (0.127 mm.) larger than the gage size it is intended to cover and shall be subject to a permissible variation of ±0.005 in. (0.127 mm.). For sizes smaller than 0.076 in. (1.93 mm.), the nominal inside diameter shall be 0.002 in. (0.0508 mm.) larger than the gage size it is intended to cover and shall be subject to a permissible variation of ±0.002 in. (0.0508 mm.).

Dielectric Strength

5. (*a*) Grade A tubing shall show an average value in the short-time dielectric strength test of not less than 7000 v., and no one of the ten puncturing voltages shall be less than 5000 v.

(*b*) Grade B tubing shall show an average value in the short-time dielectric strength test of not less than 4000 v., and no one of the ten puncturing voltages shall be less than 2500 v.

(*c*) Grade C tubing shall show an average value in the short-time dielectric strength test of not less than 2500 v., and no one of the ten puncturing voltages shall be less than 1500 v.

Heat Endurance

6. The number of hours of baking in the heat endurance test at which first cracking of the tubing occurs when bent through 180 deg. over a rod 0.32 cm. ($\frac{1}{8}$ in.) in diameter shall be not less than the following:

Grade A	96 hr., min.
Grade B	72 hr., min.
Grade C	48 hr., min.

Ignition Time

7. (*a*) Tubing furnished under these specifications as grade C non-flammable tubing shall show a value of not less than 4 seconds for ignition time and shall cease to burn immediately upon removal from the flame.

Rate of Burning

(*b*) Tubing furnished under these specifications as grade C flame-resistant tubing may ignite immediately and, on removal from the flame, the rate of burning shall be not less than 45 seconds per inch of length.

Commercial Lengths

8. The tubing shall be supplied in straight lengths of 30 or 36 in. or in continuous lengths as may be specified by the purchaser.

Packing

9. Unless otherwise specified by the purchaser, the tubing shall be packed flat in packages conforming to usual trade customs.

Marking

10. Each package shall be marked with the name or trade mark of the manufacturer, the total number of feet, and the size, number and color of the tubing.

Inspection

11. The tubing shall be inspected and tested within two weeks of the date of receipt by the purchaser.

Rejection

12. If the results of any test do not conform to the requirements prescribed in these specifications, that test shall be repeated on two additional specimens from the same lot, each of which shall conform to the requirements specified. If either of these two additional specimens fails, the lot of tubing represented by that specimen may be rejected at the option of the purchaser.

Rehearing

13. Samples of rejected material shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of test, the manufacturer may make claim for a rehearing within that time.

Methods of Testing

14. Flexible varnished tubing shall be sampled, conditioned, and tested in accordance with the Tentative Methods of Testing Flexible Varnished Tubing Used for Electrical Insulation (A.S.T.M. Designation: D 350 – 32 T) of the American Society for Testing Materials.[1]

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 902 (1932); also 1933 Book of A.S.T.M. Tentative Standards, p. 812.

TENTATIVE METHODS OF TESTING COMPOUNDS USED FOR SPLICING ELECTRICAL CABLES AND FILLING POTHEADS[1]

A.S.T.M. Designation: D 176 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1923; REVISED, 1924, 1925, 1929, 1933.

Scope

1. These methods cover tests for compounds used in cable splices and potheads.

PHYSICAL TESTS

Physical Tests

2. Each of the following tests shall be made in accordance with the method of test applicable, of the American Society for Testing Materials, as indicated:

(*a*) *Melting Point:* Standard Method of Test for Melting Point of Petrolatum (A.S.T.M. Designation: D 127).[2]

(*b*) *Softening Point,* for compounds having no definite melting point: Standard Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method) (A.S.T.M. Designation: D 36),[3] or

Standard Method of Test for Softening Point of Tar Products (Cube-in-Water Method) (A.S.T.M. Designation: D 61).[4]

The method used should be indicated in the report.

(*c*) *Flash and Fire Points:* Standard Method of Test for Flash and Fire Points by Means of Open Cup (A.S.T.M. Designation: D 92).[5]

(*d*) *Evaporation:* Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds (A.S.T.M. Designation: D 6).[6]

(*e*) *Viscosity,* Temperature range from melting point to 150° C.: Saybolt Furol, Standard Methods of Test for Viscosity of Petroleum Products and Lubricants (A.S.T.M. Designation: D 88).[7]

(*f*) *Penetration Test,* Temperature range from melting or softening point to −25° C.: Standard Method of Test for Penetration of Bituminous Materials (A.S.T.M. Designation: D 5).[8]

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. J. A. Scott, Secretary of Committee D-9 on Electrical Insulating Materials, General Electric Co., Schenectady, N. Y.

[2] 1933 Book of A.S.T.M. Standards, Part II, p. 840.

[3] *Ibid.*, p. 984.

[4] *Ibid.*, p. 989.

[5] *Ibid.*, p. 800.

[6] *Ibid.* p. 962.

[7] *Ibid.* p. 880.

[8] *Ibid.* p. 971.

Brittleness

3. To determine the brittleness of the material, the compound shall be spread on a piece of sheet metal in a layer $\frac{1}{16}$ in. in thickness. It shall then be submerged in water having a temperature at least 20° F. above the expected breaking point. It shall then be cooled 5° F. and held at this temperature for 5 minutes. The cooling shall then be continued in increments of 5° F. At each temperature interval the compounds shall be tested with the blade of a knife, inserting the point with the blade as nearly parallel with the sheet metal as is practicable, and pulling the compound from the sheet metal as rapidly as possible by rotating the blade about its back as an axis. The temperature at which the compound no longer stretches but snaps, shall be considered the breaking point.

DIELECTRIC STRENGTH TEST

Dielectric Strength

4. (*a*) This test is intended to determine the dielectric strength of cable splicing and pothead compounds under voltage stresses of short duration. It is of value as a comparative test but does not indicate the permanent dielectric strength of these compounds.

(*b*) The dielectric strength of this class of material varies with the temperature. It is, therefore, recommended that a sufficient number of tests be made at different temperatures to establish the momentary dielectric strength - temperature curve from 0 to 100° C.

Sample

5. A representative sample shall be taken from the original package, melted and poured directly into the testing container. Care should be exercised in melting and pouring the compound not to overheat it nor to entrap air. The electrodes shall be heated to the approximate temperature of the compound before filling the container.

Electrodes

6. (*a*) The testing container, after filling, shall be placed in a suitable constant-temperature air bath or oil bath and sufficient time allowed to elapse to bring the entire mass to a uniform temperature. The temperature shall be determined by a thermocouple attached to one of the metal electrode ends or by a mercury thermometer placed vertically touching an electrode and approximately $\frac{1}{2}$ in. (1.25 cm.) from the gap between electrodes.

(*b*) The test shall be made between polished hemispherical (Note 1) brass or copper electrodes $\frac{1}{2}$ in. in diameter separated by a gap of 0.1 in. (Note 2).

NOTE 1.—A convenient form of apparatus for holding the electrodes and compound is described in Appendix I. It is recognized that when liquid materials are being tested, this method is inconsistent with the Standard Methods of Testing Electrical Insulating Oils (A.S.T.M. Designation: D 117) of the American Society for Testing Materials.[1] However, since spherical electrodes are considered preferable for solid and semi-solid materials, the advantage of using spherical electrodes for all splicing compounds, whether liquid or solid, so that direct comparison can be made, is sufficiently great to justify the inconsistency with Methods D 117.

NOTE 2.—In the case of materials which cannot be broken down with the available voltage, the gap may be reduced to 0.05 in. but results will not be comparable directly with those obtained with the 0.1-in. gap.

Testing Transformer Voltage Control and Measurement

7. (*a*) The testing transformer used, methods of voltage control and measurement shall be as outlined in Section 2 of the Tentative Methods of Testing Sheet and Tape Insulating Materials for Dielectric Strength (A.S.T.M. Designation: D 149 – 33 T) of the American Society for Testing Materials.[2]

(*b*) The actual gap at the test temperature shall be determined by direct measurement or by measurement at some other temperature and computation of changes due to expansion or contraction.

Number of Specimens

8. Five specimens at a given temperature shall be tested and the average value taken as the momentary dielectric strength of the compound at that temperature.

Report

9. The report shall include the following:

(*a*) The momentary dielectric strength – temperature curve;

(*b*) The individual values of the puncturing voltage and the gap length at the various temperatures.

VOLUME RESISTANCE – TEMPERATURE CHARACTERISTICS

Volume Resistance versus Temperature

10. (*a*) This test is intended to determine the volume resistance – temperature characteristics of cable splicing and pothead compounds. It is of value as a comparative test and also may be used in determining the volume resistivity on an ohm-centimeter basis.

Temperature Range

(*b*) The volume resistance of this class of material varies with the temperature, generally decreasing rapidly with increase of temperature. It is, therefore, recommended that a sufficient number of tests be made at different temperatures to establish the volume resistance – temperature curve. To be of most significance, the test shall include determinations made up to the highest service temperatures. At room temperatures and below, the volume resistance of practically all of these compounds is so high that it cannot be measured with the ordinary galvanometer equipment.

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[1] 1933 Book of A.S.T.M. Standards, Part II, p. 1087.

[2] See p. 828.

Conductivity Cell

11. A suitable conductivity cell consisting of parallel planes, concentric cylinders, or coaxial cones shall be used in determining the volume resistance of the compound. The distance between electrodes shall not be less than 0.75 mm. (0.03 in.) nor more than 5 mm. (0.2 in.). The voltage gradient shall not exceed 200 v. per millimeter (5 v. per mil). The area of the electrode shall be sufficiently large so that the current flow can be measured, with the apparatus available, to an accuracy within 5 per cent. Electrode areas of 50 to 500 sq. cm. (7.7 to 77.5 sq in.) should prove suitable. Because of possible catalytic or corrosion effects of some compounds on certain metals, the electrodes should be nickel, gold or platinum plated.

The insulating material used to support the electrodes shall be capable of withstanding the wide temperature range to which the cell is subjected and preferably shall be of an inorganic material such as a ceramic material or suitable glass.

A test run on the empty cell shall be made over the temperature range chosen in order to determine if any leakage is present.

A conductivity cell that has been found suitable is described in Appendix II.

Sample

12. (*a*) A representative sample shall be taken from the original package, melted and poured directly into the testing container. Care shall be exercised in melting and pouring the compound not to overheat nor to entrap air in it. The quantity of the sample depends upon the capacity of the resistivity cell used, but in any case it shall be sufficient to permit three separate determinations. Before filling, the conductivity cell shall be heated to slightly above the pouring temperature of the compound.

(*b*) A suggested procedure in filling the cell, especially in the case of the higher melting compounds, is to determine the quantity of compound necessary to just fill the cell with the electrodes in position. In the case of coaxial cones or concentric cylinders the proper quantity of the heated compound shall be first poured slowly into the outer cylinder. Any bubbles which may form on the surface of the compound shall be removed by a quick application of a flame from a bunsen burner. Immediately the inner electrode shall be slowly lowered into the compound and a thermometer placed in the well.

Test

13. The conductivity cell, after filling, shall be placed in an oil or air bath having suitable temperature control and sufficient time allowed to elapse to bring the bath and cell to temperature equilibrium at each test temperature. The temperature of the cell shall be determined by two mercury thermometers placed in contact with the electrodes. The temperature of the bath shall be determined by a mercury thermometer placed near the cell. The temperature of the bath shall be within 1° C. of the test temperature when readings are taken. The temperatures of the cell thermometers shall agree within $\frac{1}{2}$° C. of each other and within 1° C. of the bath temperature when readings are taken.

Measurements and Calculations

14. The volume resistance shall be measured at each temperature in accordance with the Standard Methods of Test for Resistivity of Insulating Materials (A.S.T.M. Designation: D 257) of the American Society for Testing Materials,[1] with particular attention to Sections 8, 9, 10, 17, 18 and 19 for liquid insulating materials.

Report

15. The report shall include the following:

(*a*) The type of resistivity cell used;

(*b*) The distance between guarded and unguarded electrodes;

(*c*) The area of guarded electrode;

(*d*) The battery voltage; and

(*e*) A curve plotted from the readings obtained over the temperature range chosen showing the relation of volume resistance in ohm-centimeter units and the temperature in degrees Centigrade.

NOTE.—In lieu of the information required in Paragraphs (*b*) and (*c*), a statement of the approximate overall accuracy may be made.

COEFFICIENT OF EXPANSION

Apparatus

16. Calibrated flasks of Pyrex or quartz glass holding approximately 250 ml. to the zero mark, having necks 1 cm. in internal diameter and graduated for 25 ml. in 0.1-ml. divisions, total capacity approximately 275 ml., shall be used.

NOTE.—If it is necessary to use a small sample, then a Cassia flask holding 100 ml. with neck graduated for 10 ml. in 0.1-ml. divisions, may be used.

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[1] 1933 Book of A.S.T.M. Standards, Part II, p. 1107.

17. The cylindrical oil bath for heating the sample shall be approximately 10 in. (25.4 cm.) in inside diameter and 20 in. (50.8 cm.) in inside depth with a false bottom 1 in. from the bottom and shall have provision for circulating the oil.

NOTE.—This bath may be made as follows: A shell about 10 in. (25.4 cm.) in inside diameter and 20 in. (50.8 cm.) in inside depth is electrically heated by winding the shell with resistance wire and covering with five layers of asbestos paper. A motor-driven paddle at the bottom will give effective oil circulation.

18. A lead collar to be hung on the flask during test to prevent the oil currents of the bath from moving the flask.

Calibration

19. The capacity of the flask at the zero point and several points on the scale shall be determined by filling the flask with distilled water at a known temperature and weighing.

Procedure

20. The flask shall first be warmed slightly, then partly filled with melted compound and placed in the bath which shall then be brought to the highest temperature of the range over which the test is to extend. The flask shall then be filled to within the last milliliter marked on the neck. The bath shall be held at this temperature for not less than 30 minutes (principally to remove air bubbles) and the whole shall then be slowly cooled to room temperature (10 to 12 hours). Before starting the test, the flasks shall be examined for the presence of cavities or irregular contraction of the compound. Some compounds, after cooling below the liquid state, tend to stick to the sides of the neck of the flask. In that case it is necessary to gradually warm the neck and flow the compound to meet the rest, after which the flask is placed in the bath for an hour or so to insure equalizing the temperature.

With the compound satisfactorily placed in the flasks at the lowest temperature, the height of the column in the neck shall be read and the bath then slowly heated. Readings shall be taken at 5° C. intervals, holding the bath as constant as possible at each point until no more expansion occurs at that point, the procedure being repeated for each point until maximum temperature is reached.

Precautions

21. During the test, temperature readings shall be taken at top and bottom of the bath to detect any variation.

Until the compound is completely liquefied, intervals between readings should be three to four hours, especially between 35 and 55° C.

After becoming liquefied, the time necessary for obtaining a reading may be reduced to about 30 minutes.

Report

22. (*a*) After securing the readings over the temperature range desired, a curve shall be plotted from the temperature and flask readings from which the coefficient of expansion shall be calculated from the formula:

$$\text{Coefficient of expansion of the compound} = \frac{V_1 - V}{(T_1 - T)\ V} + C$$

where V = original volume;

V_1 = volume at higher temperature;

T = original temperature;

T_1 = higher temperature;

C = constant = coefficient of expansion of glass container.

(*b*) The coefficient shall be calculated for three ranges as follows:

(*1*) From the minimum temperature at which the measurement was made to 10° C. below the melting point. This is intended to give the average coefficient for the solid condition.

(*2*) From 5° C. above the melting point to 100° C. This is intended to give the average coefficient for the liquid condition.

(*3*) From the minimum temperature at which a measurement was made to 100° C.

In reporting the coefficient of expansion the corresponding temperature range shall be indicated in each case.

APPENDIX I

Because of the great difficulty experienced in removing most cable splicing and pothead compounds from the container and from the electrode an arrangement is desirable which is sufficiently inexpensive to permit of it being discarded fully or in part after the test. Two devices that have proved satisfactory are illustrated in Figs. A1 and A2.

Figure A1 shows the simplest device. It consists of a box about 2 in. square in cross-section and 2 in. in length inside of the wooden ends. The sides and bottom are made from a single piece of press board and are attached to wooden blocks which form the ends. Holes drilled through the wooden blocks receive the electrodes which are turned from ½ in. diameter brass rod. To facilitate adjustment of the gap length, a gage is arranged to slip over the ends of the electrode and so regulate the gap to the desired value.

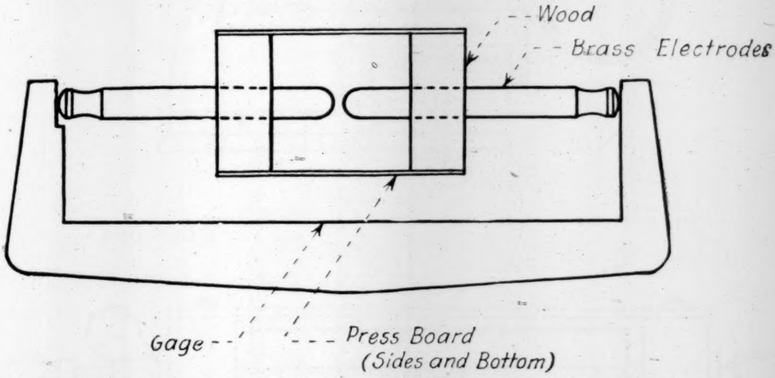

FIG. A1.—Container, Showing Electrodes in Place for Dielectric Strength Test.

Figure A2 shows a more elaborate type of testing device consisting of a framework made from laminated phenol fiber about 8 in. (20 cm.) in length and 2¼ in. (5.7 cm.) square with brass bushings centrally inserted in each end member to hold the electrode rods. A box of heavy paper or pasteboard is arranged to fit loosely inside the framework. The electrodes, which are separable by means of screw joints, are inserted through small holes in the ends of the paper box and clamped to make an oil-tight joint. The proper electrode spacing may be obtained by means of an adjusting screw on the right-hand end. Changes in the electrode spacing with temperature can be reduced greatly (to less than 0.001 in. in a change of temperature of 75° C.) by the indicated electrode design. Phenol fiber of suitable coefficient of expansion is used for supporting the brass hemispherical electrode tips and electrical connection is made by a copper wire through the center of the fiber rod. The volume of the container may be reduced to accommodate small samples by the insertion of wedges of carefully dried wood into the corners of the paper box.

APPENDIX II

A conductivity cell that has been developed for the purpose of measuring the volume resistivity as well as other electrical constants of cable splicing, pothead and similar compounds and oils is shown in Fig. A3. The concentric cylinder type of cell was chosen after experimenting with various types for the following points of simplicity and efficiency:

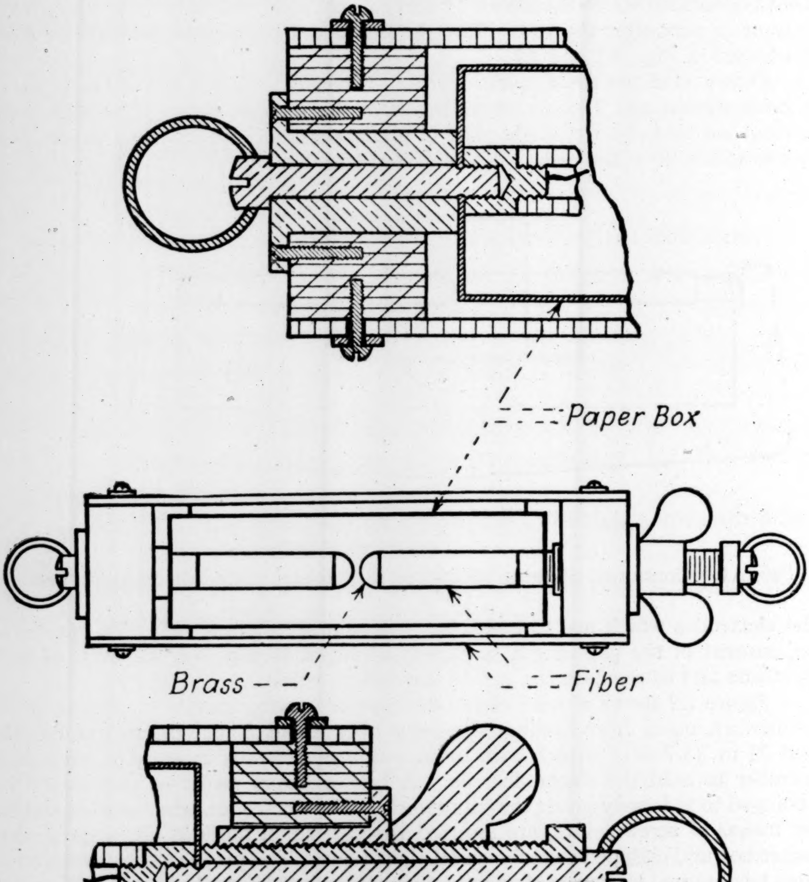

FIG. A2.—Container, Showing Electrodes in Place for Dielectric Strength Test.

1. Ease of insulating electrodes.

2. Large area of electrodes in compact form, the outer one of which also serves as container for the compound. This outer electrode is also exposed directly to the heating medium and aids in rapid changes from one temperature to another and also promotes uniform temperature distribution to the comparatively thin layer of compound in contact with it.

3. Comparative ease in assembling and disassembling cell and cleaning.

This type of cell permits the use of a very small amount of insulating material to insulate the electrodes. Mycalex has been found to be a satisfactory material for this purpose due to the fact that it can be machined to size and has good insulation resistance characteristics over the temperature range at which these compounds are normally tested. Also, it apparently is unaffected by the solvents used in the cleaning operation.

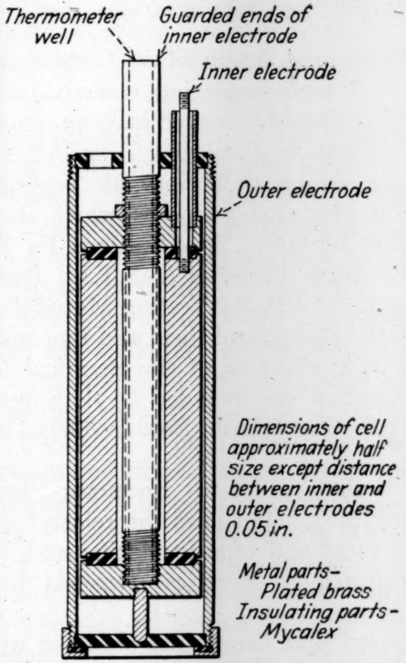
Thermometer well
Guarded ends of inner electrode
Inner electrode
Outer electrode
Dimensions of cell approximately half size except distance between inner and outer electrodes 0.05 in.
Metal parts- Plated brass
Insulating parts- Mycalex

FIG. A3.—Apparatus for Volume Resistance - Temperature Characteristics Test.

A suggested method of cleaning the cell is to remove the bottom retaining ring and to hang the cell in an oven by a hook fastened through a hole drilled in the protruding stem. Upon heating, the outer cylinder will slide away from the inner electrode and both parts will drain fairly clean of the compound. In order to speed up this cleaning, the flame of a bunsen burner may be applied directly to the cell after removing the cap and suspending the cell by the protruding stem. Further application of the flame to the cylinder and inner electrode after they separate will rapidly remove most of the compound and the final cleaning of each part can be accomplished by suitable solvents.

TENTATIVE METHODS OF TESTING SHEET AND TAPE INSULATING MATERIALS FOR DIELECTRIC STRENGTH[1]

A.S.T.M. Designation: D 149 – 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

Issued, 1922; Revised, 1923, 1924, 1926, 1927, 1930, 1931, 1932, 1933.

Scope. 1. These methods are intended to determine the dielectric strength of sheet and tape insulating materials except (*a*) rubber insulating tape, which should be tested in accordance with the Tentative Specifications for Rubber Insulating Tape (A.S.T.M. Designation: D 119 – 32 T) of the American Society for Testing Materials,[2] and (*b*) friction tape for electrical purposes which should be tested in accordance with the Tentative Specifications for Friction Tape for General Use for Electrical Purposes (A.S.T.M. Designation: D 69 – 32 T) of the American Society for Testing Materials.[2]

Since the dielectric strength of sheet and tape materials is dependent upon the time of application of the electrical tension, two tests differing in time duration are included as *A*, Short-Time Dielectric Strength Test, and *B*, One-Minute Step-by-Step Dielectric Strength Test, respectively.

A third test, designated as an Endurance Dielectric Strength Test, is included under *C*. It shows the relative dielectric strength of different flexible sheet and tape insulating materials at high temperature when subjected to electrical tensions for relatively long periods.

It should be noted that the results obtained with the electrodes specified for sheet material will differ from those specified for tape material (Section 3) and will not be comparable because the apparent dielectric strength of thin materials varies with the area of the electrodes.

Sheet materials are divisible into two general classes: (1) thin, flexible materials, easily bent or wrapped around conductors, and (2) laminated materials, slightly flexible or rigid.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. J. A. Scott, Secretary of Committee D-9 on Electrical Insulating Materials, General Electric Co., Schenectady, N. Y.

[2] *Proceedings,* Am. Soc. Testing Mats., Vol. 32, Part I, pp. 930, 926 (1932); also 1933 Book of A.S.T.M. Tentative Standards, pp. 893, 889.

(*1*) Tests on thin flexible materials at room temperature shall be made in accordance with Method *A* Short-Time Dielectric Strength Tests as specified in Sections 2 to 12; with Method *B* One-Minute Step-by-Step Dielectric Strength Test as specified in Sections 13 to 22, or with Method *C* Endurance Dielectric Strength Test as specified in Sections 23 to 28.

(*2*) Tests on laminated sheet materials at room temperature shall be made in accordance with the special instructions covered under Dielectric Strength Tests on Laminated Materials in Sections 29 to 33.

A. Short-Time Dielectric Strength Test

APPARATUS

High-Voltage Transformer.

2. (*a*) Any well-designed, high-voltage transformer connected to an alternating current supply, having as nearly a true sine wave as possible, may be used. The transformer and the source of supply of energy shall be not less than 2 kva. for voltages of 50,000 volts or less, and not less than 5 kva. for voltages above 50,000 volts. The frequency shall not exceed 100 cycles per second.

(*b*) Regulation shall be so controlled that the high-tension testing voltage taken from the secondary of the testing transformer can be raised gradually from any point and in no case more than 500 volts at a step. The control may be made by generator field regulation, with an induction regulator, or with a variable ratio auto transformer. Any method of regulating the voltage is satisfactory which does not distort the wave more than 10 per cent from a sinusoidal shape.

(*c*) The voltage may be measured by any approved method which gives root-mean-square values, preferably by means of a voltmeter connected to a special voltmeter coil in the high-tension winding of the testing transformer, or to a separate step-down instrument potential transformer. A voltmeter on the low-tension side of the transformer is satisfactory, if the ratio of transformation does not change under any test condition. An electrostatic voltmeter properly calibrated in the high-tension circuit is also satisfactory. A spark gap may be used to check the readings at very high potentials.

(*d*) Some protection is desirable in the high-tension circuit of testing transformers where the potential is 25,000 volts or over, to prevent dangerous surges and limit the current when the test specimen is punctured. It is, however, desirable to have as much energy available as possible when puncture occurs. If impedance in the form of choke coils is used in series with the high-tension terminals, it should not be greater than that which will limit the high-tension current to double the normal rated current of the testing transformer.

When a spark gap is used, a non-inductive resistance of about one ohm per volt should be inserted in series with one terminal of the spark gap, to damp high-frequency oscillations at the time of breakdown and limit the current flow. This resistance shall be as near the gap as possible. If the test is made with one side grounded, this resistance shall be on the ungrounded side of the circuit, and if neither side is grounded, the resistance shall be inserted one-half on each side of the spark gap. Water tube resistors are preferable to carbon for this purpose, as carbon resistance may be materially decreased by the passage of current.

(*e*) The apparatus used and the method of measuring the voltage shall meet the requirements of the Standards of the American Institute of Electrical Engineers.

Electrodes.

3. The electrodes shall be of brass or copper with flat polished contact surfaces. For sheet material they shall be cylinders 2 in. (50.8 mm.) in diameter and 1 in. (25.4 mm.) in length with the edges rounded to a radius of $\frac{1}{4}$ in. (6.35 mm.). For tapes the electrodes shall be cylindrical rods $\frac{1}{4}$ in. (6.35 mm.) in diameter with edges rounded to a radius of $\frac{1}{32}$ in. (0.8 mm.) and the upper movable one shall weigh 0.1 lb. (45.4 g.) ± 0.005 lb. (2.3 g.).

TEST SPECIMENS

Test Specimens.

4. (*a*) The test specimens may be of any convenient size, but the total area of the specimens of one sample of material shall be sufficient to permit making at least ten satisfactory tests.

(*b*) The specimens shall be representative of the material to be tested, care being taken to select material which is free from abnormal defects such as blisters, wrinkles, cracks, etc.

PROCEDURE

Surrounding Medium.

5. The tests shall be made in air with the specimen at room temperature.

Condition of Electrodes.

6. The testing electrodes shall be kept clean and polished.

Position of Electrodes and Specimen.

7. (*a*) The electrodes shall be self-aligning, and shall be placed exactly opposite one another with the specimen in a horizontal plane between them.

(*b*) The electrodes shall be so mounted as to preclude any surface burning of the tape whatever and to prevent flashovers. If flashovers occur either over the edge of the tape or from the upper electrode to an adjacent lower electrode, or if the punctures in the tape are accompanied by a burning or charring of the surface of the tape, all the voltage readings obtained in making the test will not be reliable and shall be discarded and a new specimen tested.

8. The edges of tapes shall be clamped between blocks of insulating material under a pressure of approximately 100 lb. per sq. in. to prevent flashover occurring before puncture.

NOTE.—In the Appendix a device is shown which has been found satisfactory for these tests.

Application of Voltage.

9. Starting at zero. the voltage shall be increased uniformly to breakdown at a rate of 0.5 kv. per seconds, except that if breakdown occurs at this rate in less than 40 seconds, the rate shall be decreased so that breakdown will occur in not less than 40 seconds. If the material fails at less than 5 kv., the minimum time shall be reduced from 40 seconds to 20 seconds.

Number of Tests.

10. Unless otherwise specified, ten tests shall be made and the average of these ten puncturing voltages shall be taken.

Thickness.

11. (*a*) The thickness shall be measured near the point of puncture with a machinist's micrometer graduated to 0.001 in. and having anvil and spindle surfaces not less than 0.24 in. and not greater than 0.26 in. in diameter.

NOTE.—The micrometers specified in the Tentative Methods of Testing Sheet and Tape Electrical Insulation for Thickness (A.S.T.M. Designation: D 374 - 33 T) of the American Society for Testing Materials[1] are suitable for this purpose.

(*b*) The number of thickness readings on the specimen shall be equal to the number of punctures made under Section 10. In the case of tapes, the readings shall be distributed along the center line of the specimen in such manner as to represent closely the thickness at the points of puncture.

Report.

12. Unless otherwise specified, the report shall include the following:

(*a*) The thickness of the specimen at each puncture;
(*b*) Total volts and volts per mil of thickness at each puncture;
(*c*) The average, maximum and minimum volts at puncture per mil of thickness for each sample;
(*d*) The room temperature;
(*e*) The relative humidity, in per cent;
(*f*) The duration of the test.

B. One-Minute Step-by-Step Dielectric Strength Test

APPARATUS

Apparatus.

13. The apparatus shall consist of the high-voltage transformer and the electrodes specified in Sections 2 and 3.

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[1] See p. 860.

TEST SPECIMENS

Test Specimens. 14. The test specimens shall be as specified in Section 4.

PROCEDURE

Surrounding Medium. 15. The tests shall be made in air with the specimen at room temperature.

Condition of Electrodes. 16. The testing electrodes shall be kept clean and polished.

Position of Electrodes and Specimen. 17. The electrodes shall be self-aligning, and shall be placed exactly opposite one another with the specimen in a horizontal plane between them.

18. The edges of tapes shall be clamped between blocks of insulating material under a pressure of approximately 100 lb. per sq. in. to prevent flashover occurring before puncture.

NOTE.—In the Appendix are shown two different devices which have been found satisfactory for these tests.

Application of Voltage. 19. An initial voltage shall be applied equal to 40 per cent of the breakdown voltage in the short-time test, adjusted as shown in the following table. The voltage shall then be increased in increments as indicated in the table, up to failure, being held at each step for one minute. The change from each step to the next higher shall be made within 10 seconds.

BREAKDOWN KILOVOLTS BY SHORT-TIME METHOD	ADJUST 40 PER CENT OF BREAKDOWN VOLTAGE TO NEAREST	INCREMENT OF INCREASE
12.5 kv. or less	0.5 kv.	0.5 kv.
over 12.5 to 25 kv., inclusive	1.0 "	1.0 "
over 25 " 50 " "	2.5 "	2.5 "
over 50 " 100 " "	5.0 "	5.0 "
over 100 "	10.0 "	10.0 "

NOTE.—*Example:*

Breakdown voltage by short-time method = 41 kv.
40 per cent of breakdown voltage = 16.4 kv.
Initial voltage obtained by adjusting 40 per cent of breakdown voltage to nearest 2.5 kv. = 17.5 kv.
Voltage will be increased in increments of 2.5 kv.
Therefore, second step = 20.0 kv., etc.

Number of Tests. 20. Five tests shall be made and the average of these five puncturing voltages shall be taken.

Thickness. 21. The thickness of the specimen shall be measured at each puncture, using a ratchet micrometer graduated to 0.001 in. and having a circular foot not less than 0.240 in. nor more than 0.260 in. in diameter.

Report. 22. The report shall include the following:

(*a*) The thickness of the specimen at each puncture;

(*b*) Total volts and volts per mil of thickness at each puncture;

(*c*) The average, maximum and minimum volts at puncture per mil of thickness for each sample;

(*d*) The room temperature;

(*e*) The relative humidity, in per cent;

(*f*) The duration of the test;

(*g*) The value of the initially applied voltage and the value of the voltage at each step.

C. Endurance Dielectric Strength Test

APPARATUS

Apparatus. 23. The apparatus shall consist of the high-voltage transformer specified in Section 2.

Test Specimen. 24. (*a*) The specimens shall be made by wrapping the material, in tape form with one-quarter lap, one-half lap, butt jointed or as sheets, on brass tubes. The tubes shall be, for sheets and for tape up to 1½ in. in width, about 36 in. in length and 1 in. in outside diameter. For tapes wider than 1½ in., the tubes shall be 2 in. in outside diameter. The sample shall be built up to the desired thickness, simulating practical conditions, winding all layers of tape in the same direction.

(*b*) A smooth layer of metal foil shall then be wrapped over the insulation for a distance of 24 in., leaving 6 in. of insulation uncovered at each end of the tube. The metal foil shall be bound in place with a wrapping of adhesive tape which shall extend the full length of the tube in order to protect the insulation at the end from corona discharge.

(*c*) A thermocouple shall be applied to the metal foil near the center of the tube and held in place by the adhesive tape.

PROCEDURE

Position of Specimen. 25. The specimen shall be mounted in an oven and a temperature of 100 C. (212 F.) maintained during the test. Provision shall be made for so mounting the specimen that the tube may be connected to the high voltage side of the circuit with the metal foil sheath and thermocouple connected to ground.

Application of Voltage. 26. A voltage equal to 10 per cent of the breakdown voltage (to the nearest kilovolt) obtained in the short-time test (Method *A*) shall be applied and maintained for 30 minutes. The voltage shall then be increased by steps of 20 per cent of the initial value until puncture occurs, the voltage being held at each step for 30 minutes.

Temperature Readings. 27. The temperature of the sample as indicated by the thermocouple shall be observed at intervals during the test and recorded at the end of each 30-minute period. It will be found that the temperature rises gradually until just before breakdown when the temperature increases rapidly. During this latter period, temperature readings shall be recorded at frequent intervals.

Report. 28. (*a*) The results shall be plotted using time, expressed in hours, as abscissas, and temperature, in degrees Centigrade, as ordinates. In addition to time as abscissas, the values of applied kilovolts shall be indicated since the value of kilovolts increases uniformly with time. The significant values to be taken from the curve and reported are:

(*1*) Duration of test;
(*2*) Breakdown voltage;
(*3*) Temperature of specimen at breakdown;
(*4*) Rate of temperature rise during test.

(*b*) The report shall also include a description of the specimen and its preparation, the thickness of the insulation and the number of layers of insulation.

Dielectric Strength Tests on Laminated Materials:

29. For testing laminated sheet materials the procedure described in Method *A*, Short-Time Tests, Sections 2 to 12 and Method *B*, Step-by-Step Test, Sections 13 to 22 shall be modified in accordance with Sections 30 to 33.

Surrounding Medium. 30. All tests shall be made under oil maintained at normal room temperature.

Conditioning. 31. Exposure to humidity has little effect on dielectric strength as long as the relative humidity is below 85 per cent. It is not necessary to condition specimens or to test them under specified relative humidities when materials are intended for use where the relative humidity does not exceed 85 per cent.

Position of Electrodes and Specimen. 32. Tests may be transverse or parallel to the laminations, or both, depending upon whether the stress on the material when in use is to be transverse or parallel to the laminations, or both.

(*a*) Transverse tests shall be made between the standard 2-in. electrodes (Section 3).

NOTE.—Surface creepage and flashover at the higher voltages may be prevented by puring around the electrodes any high-grade insulating compound which will form a good bond with the material and with the electrodes. Sealing wax and phenolic resin varnish have been successfully used under certain conditions. In applying this protective compound, care must be taken to prevent voids under the edges of the electrodes.

(*b*) For tests parallel to the laminations, the material shall be cut into sections 2 in. square. Holes shall be drilled into opposite edges of each section so as to line up with each other, the inner ends of the holes being ½ in. apart. Metal electrodes shall be used, the ends of which exactly fit the ends of the holes. Thus, in effect, the material is tested edgewise in a modified needle gap. The diameter of hole should be approximately one-fourth the thickness of the specimen. For very thin specimens it may be necessary to use a larger ratio of drill size. Results shall be expressed in total kilovolts breakdown.

Number of Tests. 33. For the Short-Time Method five tests shall be sufficient, and for the Step-by-Step Method three tests.

Tests on Both Thin and Laminated Materials at Different Temperatures:

34. Where the test materials are to be used at other than room temperature, their dielectric strength characteristic should be ascertained over the operating range of temperature.

Apparatus. 35. Temperature control shall be obtained by the use of an air oven (or refrigerator) in the case of thin materials, or by the use of an oil bath, in the case of laminated materials.

(*a*) The air oven should be provided with some means of circulating the air, so that approximately constant temperature is maintained around the test specimen, and with a thermometer or thermocouple for measuring the temperature as near the point of test as practicable. Any well-designed oven of sufficient size to hold the test equipment is satisfactory for this purpose.

(*b*) The oil bath should be provided with some means for circulating the oil, so that the temperature is substantially uniform around the test specimens, and with a thermometer or thermocouple for measuring the temperature as near the point of test as practicable.

Procedure. 36. The test material shall be subjected to the test temperature, before voltage is applied, for a period in minutes equal to half the thickness of the specimen in mils.

The tests shall cover the operating range of temperature to which the test material is to be subjected. Where this range is considerable, tests should be made at not less than four points, so that a curve of dielectric strength (volts per mil) against temperature may be plotted. These points should include the maximum and minimum operating temperatures. The number of tests at each temperature shall be as specified in Sections 10 and 33.

APPENDIX

Figure A1 shows the multiple electrode form of tape tester.[1] In this type, a strip of tape is held under pressure between rubber washers encircling the electrodes.

The washers, having center holes not smaller than ⅜ in. in diameter, are cemented to two insulating blocks, *A*, which in turn are fastened to two rigid main blocks, *B*. Upper block, *B*, is hinged along one side and fitted with catches along the other to lock the two blocks together. A handle, operating cams through a common shaft, forces lower block, *B*, upward against upper block, *B*, the latter restrained by a set of springs along each side.

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[1] **A detailed drawing of the tape tester may be obtained from Mr. J. A. Scott, Secretary of Committee D-9 on Electrical Insulating Materials, General Electric Co., Schenectady, N. Y.**

There are ten lower electrodes which are fixed to a common bus bar, *E*. The upper electrode, *G*, is movable and may be inserted into any of the bushed holes, *F*, which serve to align the upper electrode with the corresponding lower electrode. Voltage is applied between the upper and lower electrodes by direct connection to the upper electrode and by connection to the common bus bar through terminal, *T*. The electrodes are cylindrical brass rods $\frac{1}{4}$ in. (6.35 mm.) in diameter with edges rounded to a radius of $\frac{1}{32}$ in. (0.8 mm.). The weight of the upper electrode is 0.1 lb. (45.4 g.).

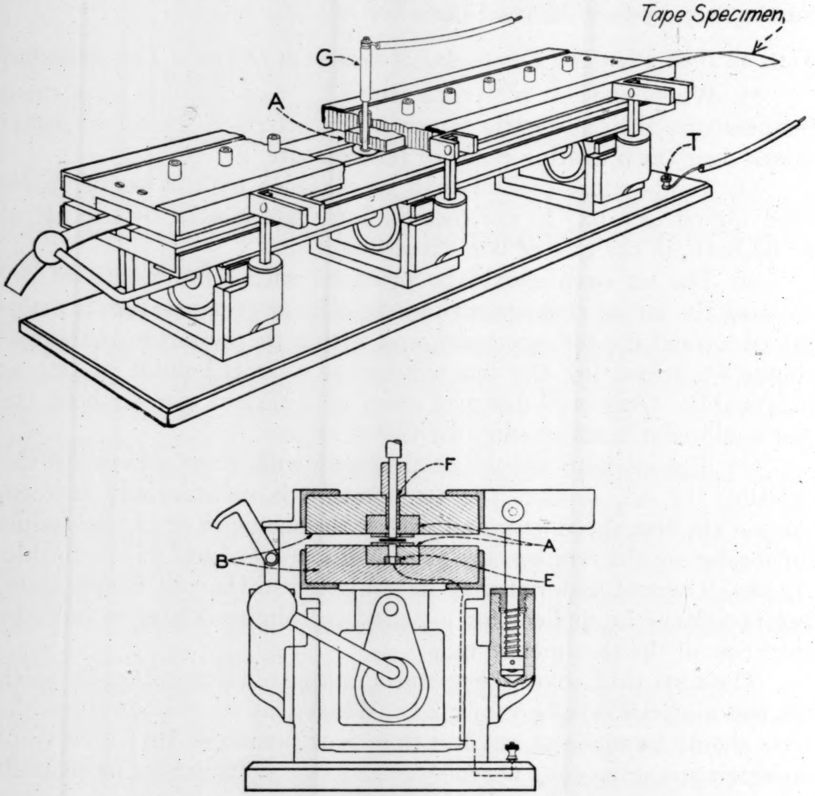

FIG. A1.—Apparatus for Dielectric Strength Test on Tape.

After the tape is secured in position, the test is made by moving the upper electrode successively from hole to hole until the specified number of punctures have been obtained.

As carbon is formed during tests, the successful operation of the device depends upon keeping the parts clean. When cleaning the electrodes, care should be taken not to change their form. The rubber washers may require replacement from time to time.

TENTATIVE METHODS OF TEST
FOR
GRADING NATURAL MICA ACCORDING TO SIZE, COMMERCIAL QUALITY, AND THICKNESS[1]

A.S.T.M. Designation: D 351 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932; REVISED, 1933.

Scope. 1. These methods cover tests for the grading of all natural block mica and mica splittings for general use according to size, commercial quality, and thickness.

GRADING ACCORDING TO SIZE

Grade. 2. Natural mica shall be graded according to the area of the usable rectangle which can be cut from the specimen and the minimum dimension of one side. The mica in the usable rectangle shall meet the quality requirements specified by the purchaser.

A.S.T.M. Chart. 3. The tentative standard A.S.T.M. chart shown in Fig. 1 (Plate I) shall be used for grading natural block mica and mica splittings according to size.

Method of Grading for Size. 4. The specimen to be graded shall be laid upon the chart so that it covers point *O* and has its maximum and minimum dimensions extending along and covering the lines *OA* and *OB*, respectively. The specimen should be shifted until its usable area completely covers the largest rectangle determined by a diagonal extending from point *O* to or beyond a point on any of the curves, Nos. 6, 5½, 5, 4, 3, 2, 1, or A-1. The number of the curve at greatest distance from *O* cut by the diagonal of the rectangle designates the grade of the specimen.

NOTE.—The A.S.T.M. chart complies closely with the following so-called India grading scale, in general use for many years:

GRADE	AREA OF RECTANGLE, SQ. IN.	MINIMUM DIMENSION OF ONE SIDE
Extra Special	60 to 79⅞	....
Special	48 to 59⅞	....
A-1	36 to 47⅞	4 in.
1	24 to 35⅞	3 in.
2	15 to 23⅞	2 in.
3	10 to 14⅞	2 in.
4	6 to 9⅞	1½ in.
5	3 to 5⅞	1 in.
5½	2½ to 2⅞	1 in.
6	1 to 2⅜	¾ in.

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[1] Criticisms of **these** Tentative Methods are solicited and should be directed to Mr. J. A. Scott, Secretary of Committee D-9 on Electrical Insulating Materials, General Electric Co., Schenectady, N. Y

DETERMINATION OF COMMERCIAL QUALITY

Commercial Quality.

5. The commercial quality of mica shall be judged in terms of the following scale:

QUALITY	DESCRIPTION
Clear	Free of all mineral and vegetable inclusions, stains, air inclusions, waves or buckles. Hard transparent sheets.
Clear and Slightly Stained	Free of all mineral and vegetable inclusions, cracks, waves, and buckles but may contain slight stains and air inclusions.
Fair Stained	Free of mineral and vegetable inclusions and cracks. Hard. Contains slight air inclusions and is slightly wavy.
Good Stained	Free of mineral inclusions and cracks but contains air inclusions, some vegetable inclusions and may be somewhat wavy.
Stained	Free of mineral inclusions and cracks but may contain considerable clay and vegetable stains and may be more wavy and softer than the better qualities.
Black Stained or Spotted	Same as Stained but contains mineral inclusions.

NOTE.—It is proposed to prepare a set of master standards complying with the above descriptions, from which sets of photographic prints or transparent autochrome plates can be furnished.

THICKNESS

Thickness.

6. (*a*) Measurements of the thickness of mica shall be determined with a machinist's micrometer as specified in the Tentative Methods of Testing Sheet and Tape Electrical Insulation for Thickness (A.S.T.M. Designation: D 374 – 33 T) of the American Society for Testing Materials.[1] In determining thickness of mica which must be held to close tolerance or where two or more specimens are to be measured at once, Method A shall be used. Where the maximum accuracy is not required, Method B may be used.

(*b*) Because of the abrasive nature of mica, the micrometer shall be tested frequently for conformity to the requirements specified in the Tentative Methods D 374. The anvil and spindle shall be cleaned as frequently as necessary to prevent the accumulation of mica dust on their surfaces and to preserve the accuracy of the measurements. To clean, the micrometer shall be closed lightly on a clean sheet of bond paper and the paper moved between the surfaces.

NOTE.—Care must be exercised in moving from one measurement location to another to maintain the surfaces of the anvil and spindle parallel to the surfaces of the specimen at all times so as to avoid scratching the mica and accumulating mica dust under the micrometer surfaces which will cause false readings.

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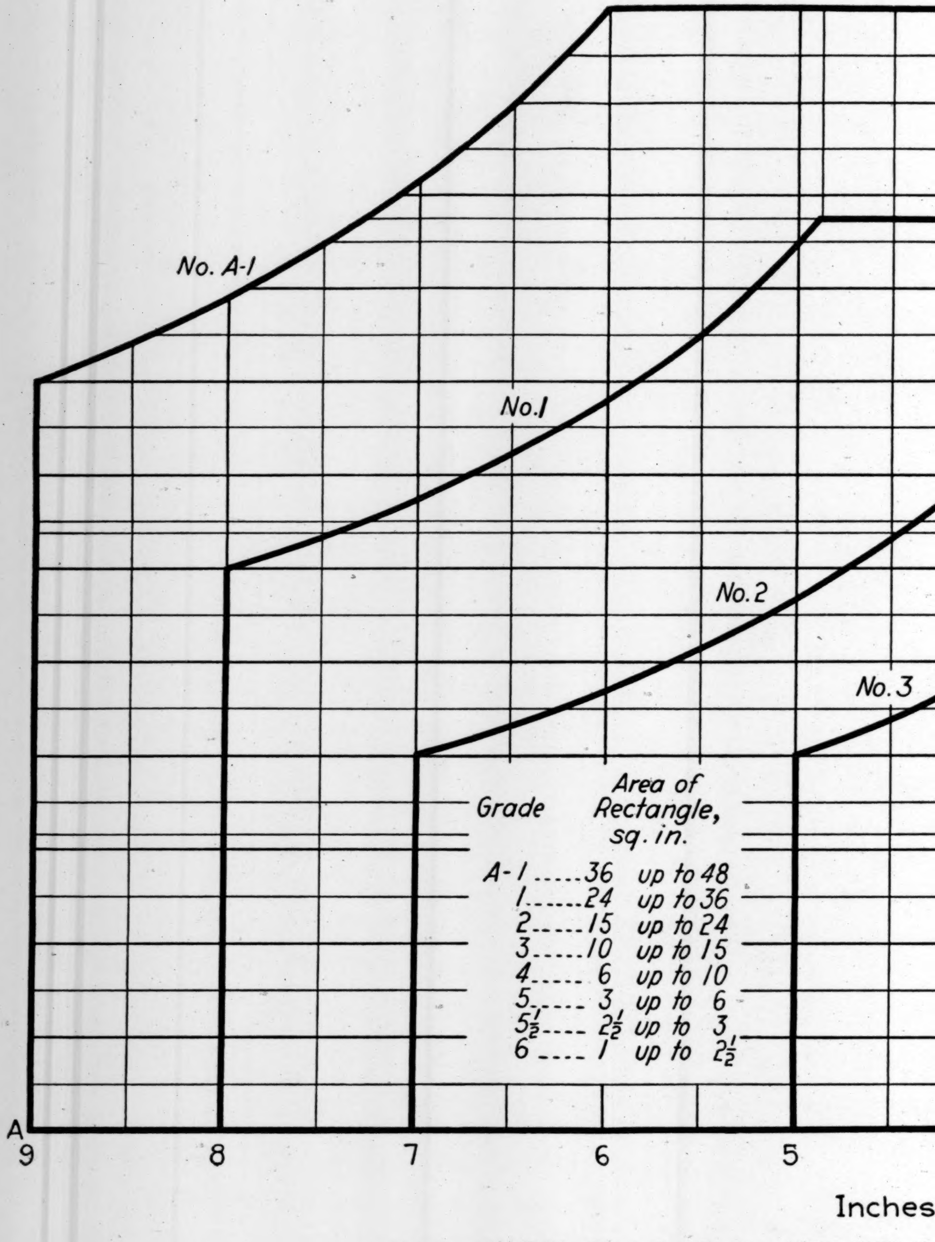
[1] See p. 860.



Grade	Area of Rectangle, sq. in.
A-1	36 up to 48
1	24 up to 36
2	15 up to 24
3	10 up to 15
4	6 up to 10
5	3 up to 6
5½	2½ up to 3
6	1 up to 2½

FIG. 1.—A.S.T.M. Chart for Grading Natural Block

PLATE II.
PROCEEDINGS, AM. SOC. TESTING MATS.
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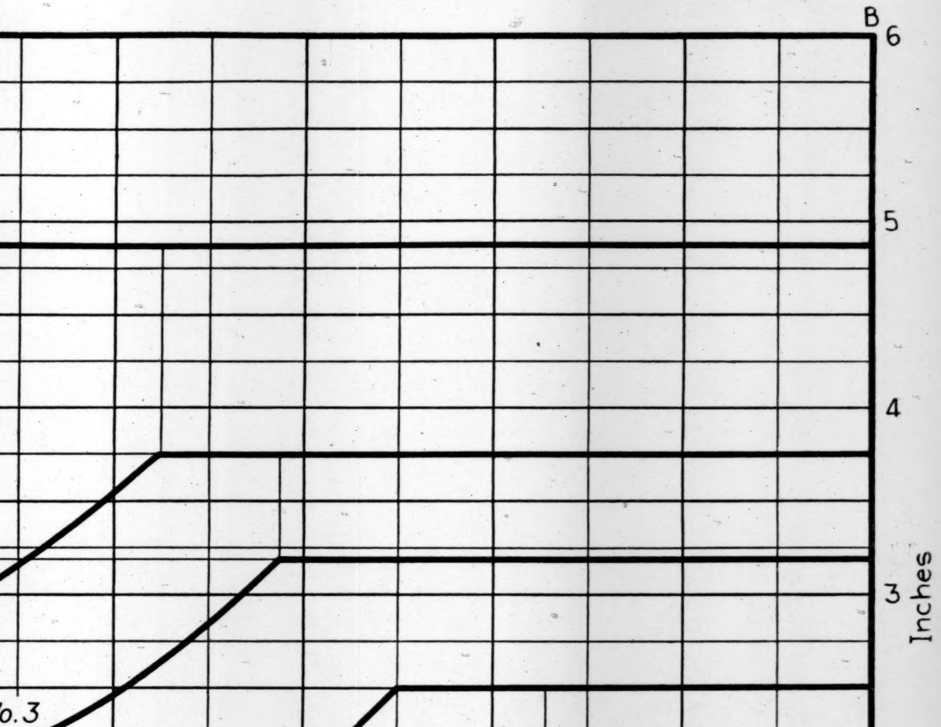
TENTATIVE METHODS OF TEST FOR
GRADING NATURAL MICA



Block Mica and Mica Splittings According to Size.

TENTATIVE METHODS OF TESTING UNTREATED PAPER USED IN ELECTRICAL INSULATION[1]

A.S.T.M. Designation: D 202 - 33 T

This is a Tentative Standard, published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1924; REVISED, 1925, 1926, 1927, 1928, 1929, 1930, 1932, 1933.

Scope.

1. These methods are intended to apply to untreated paper to be used as an electrical insulator or as a constituent of a composite material used for electrical insulating purposes.

SAMPLING

Sampling.

2. (*a*) From shipments consisting of rolls, a sample of at least 1 sq. yd. in area, cut across the entire width of the roll, shall be taken from every tenth roll in the shipment. From other shipments such as sheets or pads of tape, samples of equivalent area shall be taken in such a manner as to be equally representative of the shipment. In no case shall less than three samples be taken.

NOTE.—It is recommended that several turns of paper from each roll sampled be torn off and discarded before the samples are taken.

(*b*) The tests for physical properties shall be made upon each sample.

(*c*) The tests for acidity, moisture content, size,[2] ash and for identification of fibers[2] shall be made in duplicate upon portions taken from a composite sample. This composite sample shall be made up of a sufficient number of small pieces, each of approximately 6.5 sq.cm. (1 sq. in.) in area taken in nearly equal amounts from each of the samples taken in accordance with Paragraph (*a*).

(*d*) The required number of samples shall be taken at equal intervals across the sheet, the two end samples being taken at the edges of the sheet after removing any damaged paper. When it is not possible to secure the required number of specimens in this manner in going once across the sheet, the selection across the sheet shall be repeated as many times as necessary until the required number of specimens is secured.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. J. A. Scott, Secretary of Committee D-9 on Electrical Insulating Materials. General Electric Co., Schenectady, N. Y.

[2] The tests for size, identification of fibers, and folding endurance do not appear in these methods but will be included as soon as the tests are developed by the committee.

CONDITIONING SAMPLES

Conditioning. 3. Samples shall be conditioned in air maintained at a relative humidity between 60 and 65 per cent as measured with a sling psychrometer or its equivalent. The temperature of the air shall be maintained as constant as possible at some temperature between the limits of 20 and 30° C. (68 and 86° F.). The samples should remain in the conditioned air for not less than 4 hours prior to the tests and should be supported so as to allow a free circulation around each sample. The following physical tests shall be made in the conditioned air: tensile breaking strength, tearing strength, bursting strength, folding endurance,[1] air resistance, dielectric strength and thickness.

MOISTURE CONTENT

Apparatus. 4. A weighing bottle, evaporating dish, thermometer, constant-temperature oven, chemical balance and desiccator are necessary for the test. The weighing bottle should be of convenient size, about 65 mm. (2.56 in.) in height and 45 mm. (1.77 in.) in diameter with a wide mouth provided with a ground-glass stopper. The chemical balance should be sensitive to 0.1 mg.

Specimen. 5. The moisture content figure is used to calculate the percentage of acidity, size, and ash of the paper to the bone-dry basis. It shall be determined on 2 to 5-g. samples selected in accordance with Section 2 (*c*).

If the moisture content of the paper as received at the purchaser's works is desired or at any other stated time, it shall be made on the sample taken at the definitely stated time by cutting small pieces of approximately 6.5 sq. cm. (1 sq. in.) in area from the required number of rolls or pads of tape in accordance with Section 2 (*a*) and immediately placed into an air-tight container.

NOTE.—Since paper adjusts itself, as regards moisture content, to the humidity of the surrounding atmosphere in a very short time (2 or 3 minutes), special care must be exercised to transfer rapidly the sample from the roll or bundle to the container and from the container to the weighing bottle.

Procedure. 6. The sample before drying shall be weighed in the tared bottle with the stopper in place. The bottle shall then be placed in the oven at 100 to 105° C. (212 to 221° F.), the stopper removed and laid alongside of the bottle and the contents transferred to the drying dish. After one hour, while still in the oven, the sample shall be replaced in the weighing bottle, and the bottle stoppered and transferred to the desiccator. The stopper should be removed while the bottle cools. When the specimen and the bottle have cooled to room temperature, the stopper shall be replaced and the bottle with its contents weighed. This process shall be repeated at intervals of one hour until the difference in weight between two successive weighings is not more than 0.2 per cent of the weight of the specimen.

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[1] The tests for size, identification of fibers, and folding endurance do not appear in these methods but will be included as soon as the tests are developed by the committee.

NOTE.—The weighing bottle or sample should not be touched with the fingers during this test.

Report. 7. The moisture content shall be expressed:

(*a*) as a percentage of the weight of the dry sample, and

(*b*) as a percentage of the weight of the undried sample.

THICKNESS

Apparatus. 8. The thickness shall be determined in accordance with the Tentative Methods of Testing Sheet and Tape Electrical Insulation for Thickness (A.S.T.M. Designation: D 374 – 33 T) of the American Society for Testing Materials.[1]

Specimens. 9. Specimens shall consist of the original samples obtained in accordance with Section 2 (*a*).

Number of Measurements. 10. At least five measurements of the thickness shall be taken at regular intervals across the entire width of each specimen.

Report. 11. The average, maximum, and minimum thicknesses obtained on each specimen shall be reported.

TENSILE BREAKING STRENGTH

Apparatus. 12. (*a*) A testing machine of the dead-weight pendulum type suitably designed for testing paper shall be used. The machine shall preferably be power driven.

(*b*) The capacity of the machine shall not exceed 113 kg. (250 lb.).

(*c*) The machine shall be graduated to read 1 lb. or 1 kg. or less per scale division for testing paper breaking at 22.7 kg. (50 lb.) or over, and to 0.5 lb. or 0.5 kg. or less for testing paper breaking under 22.7 kg. (50 lb.).

Specimens. 13. From each of the samples selected in accordance with Section 2 (*a*), specimens shall be cut at least ten in the machine direction and if practicable, ten in the cross-machine direction. The specimens shall not exceed 2.54 cm. (1 in.) in width and shall be 25.4 cm. (10 in.) in length with clean-cut edges.

Procedure. 14. (*a*) The ratio of the clearance distance between jaws to the width of the specimen shall not be less than 5 to 1 nor more than 10 to 1.

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[1] See p. 860.

(*b*) The rate of travel of the movable jaw shall be constant. It shall preferably be 30.5 cm. (12 in.) per minute, but it may be within the limits of 28 cm. (11 in.) and 33 cm. (13 in.) per minute provided it is constant.

(*c*) All readings obtained when the paper breaks at or in the jaws shall be rejected.

Report. 15. (*a*) The results of the machine-direction specimens and the cross-machine-direction specimens shall be reported separately.

(*b*) The results shall be reported in kilograms or pounds together with the width of the specimen in centimeters or inches and also the average thickness.

(*c*) The maximum, minimum, and average breaking load shall be reported for the machine direction and the cross-machine direction.

TEARING STRENGTH

Apparatus. 16. The testing machine shall be of the pendulum impulse type so designed as to produce a tear approximately 4.2 cm. (1.66 in.) long. The knife mounted on the machine to cut the slit for the tear shall be maintained sharp.

Specimen. 17. The specimens shall be taken from the original samples obtained in accordance with Section 2 (*a*) and shall be cut 6.3 cm. (2.5 in.) in width and at least 6.3 cm. (2.5 in.) in length. Enough specimens shall be cut so that at least five readings in the machine direction and five readings in the cross-direction, if possible, can be obtained for each original sample.

Method. 18. Enough paper shall be torn so that the readings on the machine shall be not less than 10 nor more than 20 g., unless one paper alone yields a reading greater than 20 g., in which case only one paper shall be torn at one time. The specimens shall be so arranged that an equal number of tears originating from opposite edges of the specimens will be produced. Readings obtained when a tear deviates more than 6.3 mm. (0.25 in.) from a straight line, shall be rejected. The readings obtained shall be multiplied by the instrument constant corresponding to the number of sheets torn.

Report. 19. (*a*) The tearing strengths obtained on the machine-direction specimens and on the cross-direction specimens shall be reported separately in grams.

(*b*) The average, the maximum, and the minimum tearing strengths shall be reported for the machine-direction specimens. If possible, similar results shall be reported for the cross-direction specimens.

BURSTING STRENGTH

Apparatus. 20. The testing machine shall have a circular flexible diaphragm 6.44 sq. cm. (1 sq. in.) in area. The pressure chamber shall be filled with glycerin or other suitable pressure medium and shall contain no air spaces. The test specimen shall be held in position over the diaphragm in a clamp having a circular hole approximately 6.44 sq. cm. (1 sq. in.) in area so that the diaphragm will force the paper into the hole when pressure is applied under the diaphragm. The pressure exerted on the diaphragm shall be indicated on a dial, graduated to at least 0.23 kg. (0.5 lb.) for papers giving bursting strengths 18 kg. (40 lb.) or under. A dial graduated 0.45 kg. (1 lb.) may be used in testing papers which give higher bursting strengths. The machine may be either hand-operated or power-driven, the latter being preferable.

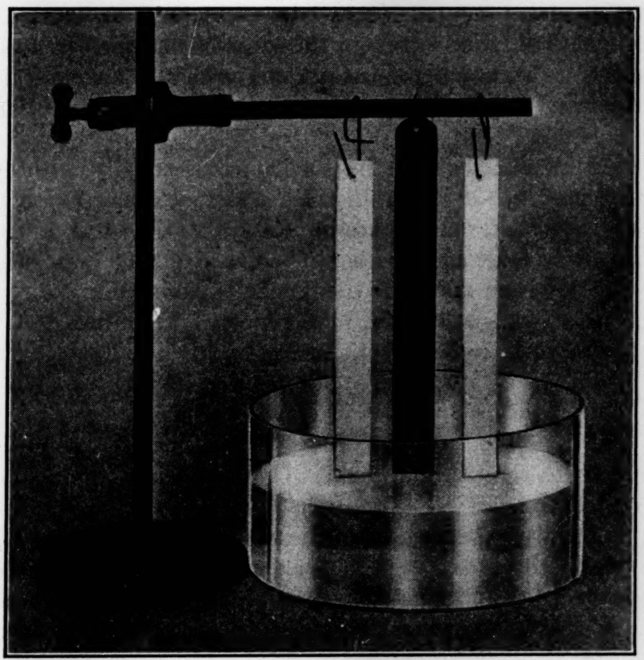

Fig. 1.—Apparatus for Absorption Test.

Specimen. 21. If practicable, the specimen shall be so cut from the stock as to permit ten bursting tests on a line across the sheet or roll.

Procedure. 22. Ten bursts shall be made, five with one side of the paper uppermost and five with the other side uppermost. The testing machine shall be driven at a uniform speed of 120 r.p.m. until the specimen bursts.

Report. 23. The report shall include the average, the maximum, and the minimum results obtained.

ABSORPTION

(RISE OF WATER)

Apparatus. 24. A suitable container and support for specimens and scale is shown in Fig. 1.

Specimens. 25. Ten strips 2.5 cm. (1 in.) in width and at least 12.5 cm. (5 in.) in length shall be cut from the samples obtained in accordance with Section 2 (*a*), five being cut parallel with the machine direction of the paper and five being cut parallel with the cross-direction of the paper.

Procedure. 26. The specimens shall be suspended vertically with one end dipping 3.2 mm. (0.125 in.) in distilled water at room temperature.

After five minutes of suspension, the rise of the water in the paper above the water level shall be noted. The rise may be measured by reading directly from the scale the height of absorption.

Report. 27. The rise of water shall be reported in millimeters to the nearest 3 mm. or in inches to the nearest $\frac{1}{8}$ in.

MIL WEIGHT PER REAM

(APPARENT DENSITY)

Apparatus. 28. A scale, sharp knife, chemical balance and weighing bottle are necessary for the test.

Specimens. 29. Duplicate specimens shall be taken from as widely separated portions as possible from each of the samples obtained in accordance with Section 2 (*a*) and conditioned in accordance with Section 3.

Procedure. 30. (*a*) Each specimen while in the conditioned atmosphere (see Section 3) shall be cut accurately to any convenient size, for example, 232.3 sq. cm. (36 sq. in.) in area, and accurately weighed. Specimens of sufficient size to weigh at least from 3 to 5 g. (0.11 to 0.18 oz.) should be taken. If it is not possible to do the weighing in the conditioned atmosphere, the specimen shall be placed in a weighing bottle and tightly stoppered with a ground glass stopper before being removed from the conditioned atmosphere. The thickness of each specimen shall be determined in accordance with Sections 8 to 11.

(*b*) *Mil Weight per Ream of Any Size.*—The mil (or point) weight in pounds per ream of any size may be calculated from the following formula:

$$W = 0.002205 \frac{mSN}{ta}$$

where m = the weight of the specimen expressed in grams;

t = the average thickness of the specimen expressed in mils (thousandths of an inch);

a = the area of the specimen expressed in square inches;

S = the area of one sheet in the basic ream expressed in square inches;

N = the number of sheets in the ream.

NOTE.—0.002205 is contracted from 0.00220462.

NOTE.—The following formulas may be used to calculate the mil weight in pounds per ream for reams of particular sizes, provided a specimen of exactly 232.3 sq. cm. (36 sq. in.) is used:

Ream of 24 by 36 in., 480 sheets.

$$W = 25.40 \frac{m}{t}$$

where m = the weight of specimen expressed in grams;

t = the average thickness of the specimen in mils (thousandths of an inch).

25.40 is contracted from 25.3972224.

Ream of 24 by 36 in., 500 sheets.

$$W = 26.45 \frac{m}{t}$$

where m and t are the same as above and 26.45 is contracted from 26.45544.

NOTE.—The ream weight may be obtained from the above formulas by omitting the thickness "t".

(c) *Weight per Unit Volume.*—The weight in pounds per cubic foot (density) may be calculated from the following formula:

$$D = 3810 \frac{m}{ta}$$

where m = the weight of the specimen expressed in grams.

t = the average thickness of the specimen expressed in mils (thousandths of an inch).

a = the area of the specimen expressed in square inches.

NOTE.—3810 is contracted from 3809.58336.

NOTE.—To convert weight in pounds per cubic foot to mil weight in pounds per ream of 24 by 36 in., 480 sheets, multiply by 0.24; to convert to mil weight in pounds per ream of 24 by 36 in., 500 sheets, multiply by 0.25.

Report.

31. The weight in pounds per cubic foot or the mil weight per ream shall be reported. The size of the ream must be given when the mil weight per ream is reported.

AIR RESISTANCE

Apparatus.

32. (*a*) The instrument shall consist of two aluminum open-top cylinders, one of which is inverted and slides into the other which is fixed. The movable cylinder shall be provided with a circular aper-

ture in the closed end and a flat ring clamp for holding the paper specimen across this aperture.

(*b*) The fixed cylinder shall be 25.4 cm. (10 in.) in height and shall have an external diameter of 8.60 cm. (3.38 in.) and an internal diameter of 8.25 cm. (3.25 in.). Four slender bars, each 18.5 cm. (7.3 in.) long, 3 mm. (0.12 in.) wide and approximately 1.5 mm. (0.06 in.) thick shall be mounted vertically and equi-distantly on the inner surface of the fixed cylinder to act as guide tracks for the movable cylinder. The movable cylinder shall be graduated in units of 50 ml. and shall have a total range of 350 ml. It shall be 25.4 cm. (10 in.) high and shall have an external diameter of 7.62 cm. (3.00 in.) and an internal diameter of 7.35 cm. (2.90 in.). It shall weigh, including the flat ring clamp and the two knurled nuts, 567 g. ± 0.5 g. (20 oz. ± 0.018 oz.). The movable cylinder and the flat ring clamp shall have a concentric circular aperture of 6.44 sq. cm. (1.00 sq. in.) in area. When this aperture is too large for the specimen a similar movable cylinder and flat ring clamp having a concentric circular aperture of 1.61 sq. cm. (0.25 sq. in.) in area shall be used.

NOTE.—Results obtained with apertures of different areas are not directly proportional to the areas of the apertures. The proportionality factor must be determined by experiment.

Specimen. 33. The specimens shall be not less than 3.5 cm. (1.36 in.) nor more than 5.1 cm. (2.0 in.) in width cut from the original samples, taken in accordance with Section 2 (*a*) and shall be as long as the width of the original roll of paper. If the specimens are selected from pads of tape they shall be not less than 2.1 cm. (0.81 in.) nor more than 5.1 cm. (2.0 in.) wide and at least 30 cm. (12 in.) long. There shall be as many specimens as there are original samples.

Procedure. 34. The fixed cylinder shall be placed on a rigid support so that its sides are vertical. A lubricating oil with viscosity of 60 to 70 seconds Saybolt at 37.8° C. (100° F.) shall be placed in it to a depth of 12.7 cm. (5 in.). The specimen (one thickness only) shall be secured tightly under the clamp on the movable cylinder completely covering the aperture. The movable cylinder is then floated on the lubricating oil. The time required for the displacement of a certain amount of air shall be noted with a stop-watch. If possible, the amount of air displaced should be such that the time of displacement is not less than 20 seconds. The apparatus with its content of lubricating oil shall be at the temperature of the conditioning room when the readings are taken. The time in seconds required for the displacement of 100 ml. (6.1 cu. in.) of air through a circular area (one side only) of 6.44 sq. cm. (1 sq. in.) of the paper is known as the air resistance of the paper.

NOTE.—The clamp shall be tested for leakage by substituting a piece of tinfoil 0.05 mm. (0.002 in.) in thickness for the paper and testing in the manner described above. When so tested, the leakage shall not exceed the rate of 50 ml. in five hours.

The proper procedure for clamping the specimen or tinfoil is to turn both knurled nuts down onto the clamp simultaneously. If only one nut at a time is turned down, the clamp will not fit flat on the specimen and will consequently have an avoidable leak.

Oil is used in preference to distilled water because it does not corrode aluminum whereas distilled water does.

Precautions should be taken to avoid subjecting the apparatus to vibration as this condition would increase the rate of air displacement.

35. The report shall include the following: **Report.**

(*a*) the number of seconds required for the displacement of 100 ml. (6.1 cu. in.) of air;

(*b*) the area of paper through which the air was displaced;

(*c*) the thickness of the paper as obtained under Sections 8 to 11;

(*d*) the room temperature.

NOTE.—The following values show the probable accuracy obtainable in the air-resistance tests:

AIR RESISTANCE	ACCURACY
40 seconds	± 5 per cent
100 seconds	± 6 per cent
200 seconds	± 8 per cent
300 seconds	± 10 per cent

ASH

36. A suitable crucible such as platinum, nickel or porcelain, a balance sensitive to 0.1 mg., and a desiccator are necessary for the test. **Apparatus.**

37. Not less than 2 g. of dry, finely-divided paper from the "moisture determination" sample as obtained in accordance with Section 6 shall be used. **Specimen.**

38. The sample shall be transferred rapidly from the weighing bottle containing the dried sample into the crucible. The weighing bottle shall immediately be re-stoppered and re-weighed, and the exact weight of the sample obtained by taking the difference in weights of the weighing bottle and the sample. The sample shall be completely ignited in the crucible, preferably in a muffle furnace, all precautions being taken to prevent loss of ash or sample. The residue of incombustible mineral matter (ash) shall be desiccated, cooled and weighed, and the amount computed as a percentage of the weight of the dried sample. **Procedure.**

39. The amount of ash shall be reported as a percentage of the weight of the dry sample (see Section 7 (*a*)) and also as a percentage of the weight of the undried sample (see Section 7 (*b*)). **Report.**

ACIDITY OR ALKALINITY

Apparatus. 40. (*a*) A hot water bath, electric hot plate, motor with stirrer, 50-ml. glass burette graduated to 0.1 ml., 250-ml. wide-mouth Erlenmeyer flasks, thermometer graduated to 1° C., covering the range from 50 to 100° C., and a filtering apparatus, are required for the test.

(*b*) The Erlenmeyer flasks and the stirrer shall be of acid-resistant and alkali-resistant glass. The stirrer shall consist of a glass shaft, one end of which shall be fitted to a chuck attached to the motor shaft (see Fig. 2). The other end of the stirrer shall be fashioned into a two-bladed propeller, each blade to be approximately 15 mm. (0.59 in.) long and 6 mm. (0.24 in.) wide. The pitch of the blades and the direction of rotation shall be such as to produce a downward current along the glass shaft when the stirrer is rotated in the liquid, thus preventing spattering.

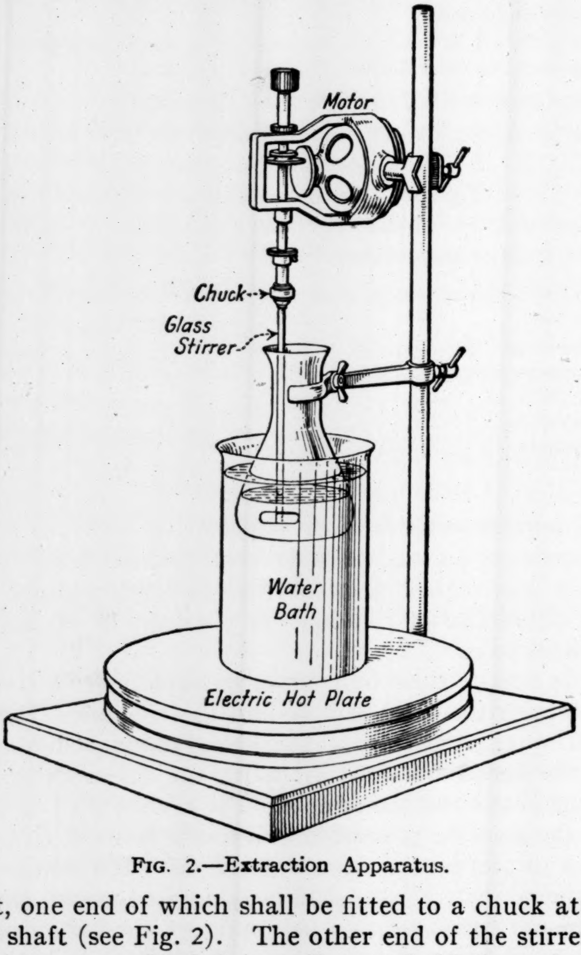

FIG. 2.—**Extraction** Apparatus.

(*c*) The following reagents shall be required: Solutions of sodium hydroxide (NaOH) and sulfuric acid (H_2SO_4) in water, each being 0.01 *N* in strength; solution of 0.5 g. of phenolphthalein dissolved in 100 ml. of c.p. ethyl alcohol.

Sample.

41. From the original samples obtained in accordance with Section 2 (*a*), a composite sample of at least 5 g. (0.175 oz.) shall be cut into small pieces, approximately 1 cm. (0.4 in.) square. The sample shall be thoroughly mixed, and during preparation contamination by handling shall be avoided.

Procedure.

42. (*a*) *Extraction.*—One gram of the composite sample shall be placed in a 250-ml. Erlenmeyer flask and 100 ml. of boiling, distilled water added. The flask shall then be clamped in position in a water bath[1] heated to 100° C. on a hot plate. The level of the water in the bath shall be slightly above the level of that in the flask, and the temperature of the contents of the flask shall remain at least as high as 95° C. during the stirring operation. The stirrer shall be mounted so that the blades are within 3 mm. (0.12 in.) of the bottom of the flask and offset from the center in order to obtain best beating action. The stirrer shall be driven at a speed of 4000 to 5000 r.p.m. for 5 minutes. At the end of this period the sample should have been thoroughly pulped. For papers unusually difficult to pulp, the period of stirring shall be increased to 10 minutes.[2]

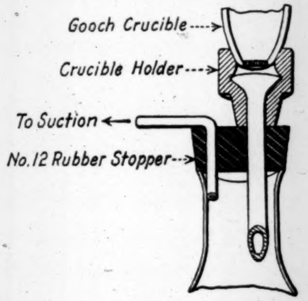

FIG. 3.—Filtration Apparatus.

NOTE.—It has been definitely determined that 3000 r.p.m. is too low to pulp the sample effectively within 5 minutes.

(*b*) *Titration.*—Immediately after the sample has been pulped, the contents of the flask shall be filtered rapidly into another 250-ml. Erlenmeyer flask without washing.

NOTE.—It is important that the filtration of the extract be accomplished as promptly as possible after disintegration to prevent re-absorption of acidic or alkaline

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[1] At high altitudes a salt bath will be necessary to obtain the temperature required.

[2] Any other method of pulping the sample as rapidly and thoroughly, while maintaining a temperature of 95° C. within the flask during extraction, should prove satisfactory.

material from the extract by the pulp as the temperature falls. A convenient method consists of a 25-ml. porcelain Gooch crucible and holder assembly, like that shown **in Fig. 3. The pulp forms a filter mat of itself over the perforations in the bottom of the crucible and the first portion of the filtrate is re-filtered to catch the fibers which go through during the formation of the mat.**

The filtered extract shall be boiled for 3 minutes and immediately titrated before the temperature falls below 80° C., thus eliminating the error due to dissolved carbon dioxide.

If the extract is acidic, it is titrated with $0.01N$ NaOH, using 5 drops of the specified phenolphthalein solution as indicator. The end-point is determined by the appearance of a definite pink color. If the extract is alkaline, a small excess of $0.01N$ H_2SO_4 is added and the titration then completed with $0.01N$ NaOH as described above.

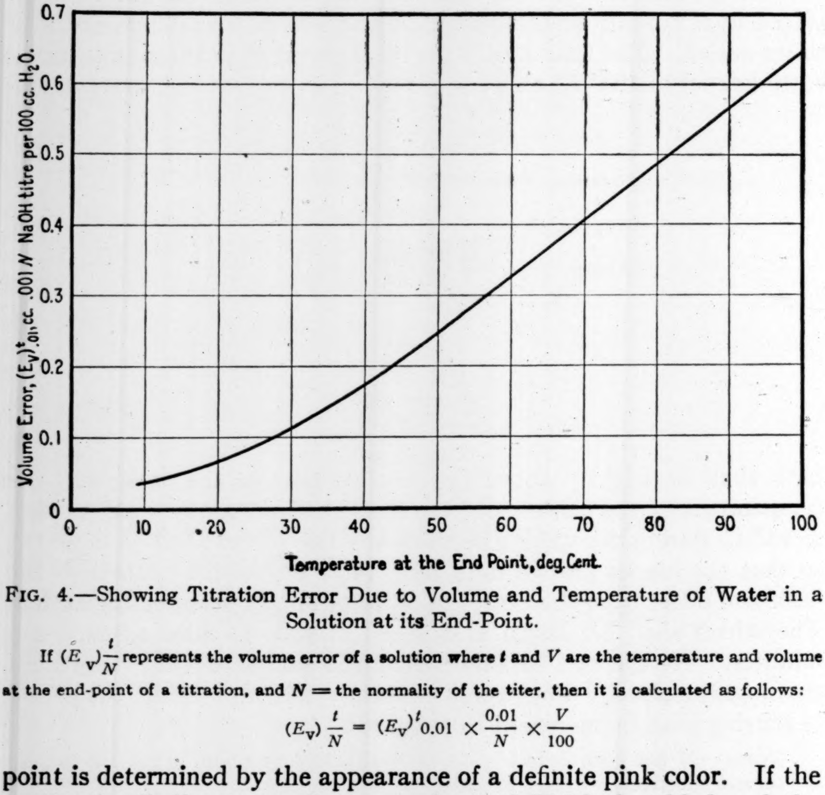

FIG. 4.—Showing Titration Error Due to Volume and Temperature of Water in a Solution at its End-Point.

If $(E_V)\frac{t}{N}$ represents the volume error of a solution where t and V are the temperature and volume at the end-point of a titration, and N = the normality of the titer, then it is calculated as follows:

$$(E_V)\frac{t}{N} = (E_V)^t 0.01 \times \frac{0.01}{N} \times \frac{V}{100}$$

NOTE.—**To find the proper color transformation at the end-point, a blank titration should be made on boiling distilled water under the above specified conditions. The result should check with the curve shown in Fig. 4. This curve will be found valuable as a check on the purity of the distilled water used, although its chief purpose is to indicate the proper blank correction to be applied to the titration.**

The number of milliliters of titer solution shall be recorded, together with the temperature and volume of the solution taken immediately upon the completion of the titration, as these figures enter into the blank correction for the volume error (E_v).

Report.

43. (*a*) *Blank Correction.*—The correction for the blank error in the titration shall be made in either of two ways:

(*1*) By running a blank in parallel with the actual determination using a volume of pure distilled water equal to that of the extract at the end-point;

(*2*) By calculating the blank error with the aid of the curve shown in Fig. 4.

NOTE.—The second method is the more convenient and probably more reliable. This curve shows the number of milliliters of 0.01 N NaOH solution required to produce an end-point at various temperatures in 100 ml. of distilled water, using 5 drops of the specified indicator. Correction by the use of this curve is valid only if the solution has been boiled and titrated at elevated temperatures to insure absence of dissolved CO_2.

This correction is the number of milliliters of titer solution (volume error) corresponding to the point on the curve determined by the temperature and volume of the solution at the end-point. If the solution is acidic, this blank correction shall be subtracted from the volume of titer used; if alkaline the correction shall be added.

(*b*) *Calculation.*—The acidity or alkalinity shall be calculated from the following equation:

$$\text{Percentage acidity (or alkalinity)} = \left\{\begin{matrix}\text{milliliters titer}\\ \text{solution (corrected)}\end{matrix}\right\} \times \frac{\text{normality}}{1000} \times 40 \times 100$$

A simpler form is:

$$\text{Percentage acidity (or alkalinity)} = \left\{\begin{matrix}\text{milliliters}\\ \text{titer (corrected)}\end{matrix}\right\} \times \text{normality} \times 4.$$

(*c*) *Expression of Results.*—The results shall be expressed as the equivalent weight per cent of NaOH if the extract is acidic, or as equivalent weight per cent of SO_3 if the extract is alkaline; this percentage being based on the weight of the air-dry sample in grams.

NOTE.—SO_3 is used rather than H_2SO_4 in this calculation as the equivalent weight of SO_3 is identical with that of NaOH, and this makes it possible to express acidity or alkalinity in directly comparable terms.

(*d*) *Number of Tests.*—At least two samples shall be carried through the foregoing procedure. If in duplicate samples the values of percentage acidity or alkalinity do not agree within 0.005, the determinations shall be repeated.

NOTE.—There is given in an appendix to the report of Committee D-9 for 1926,[1] information regarding the details of the foregoing method, and reasons are presented for the selection of the conditions specified.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 461 (1926).

SURVEY FOR CONDUCTING PATHS

Scope. 44. The survey for conducting paths in untreated insulating paper is a test to determine the number of conducting paths in the paper as indicated by the number of electrical breakdowns (or points of excessive current flow in thin papers (see Section 47 (*b*)) when relatively large areas of the paper are subjected to a voltage somewhat lower in value than the dielectric strength of the paper when tested in accordance with Sections 2 to 12 of the Tentative Methods of Testing Sheet and Tape Insulating Materials for Dielectric Strength (A.S.T.M. Designation: D 149 – 33 T) of the American Society for Testing Materials.[1]

Apparatus. 45. (*a*) The survey shall be made by passing a specimen of the paper between metallic electrodes across which a voltage is impressed. The arrangement of the apparatus may be of any convenient form which will allow the application of the required voltage to a specimen of relatively large area, and will allow the electrical breakdowns to be indicated so that the number of these may be counted.

(*b*) For papers having a thickness of 0.038 mm. (0.0015 in.) or less it has been found preferable to use a detecting device such as a telephone receiver to detect the excessive current through the conducting paths rather than to allow complete electrical breakdown of the specimen. Also, it is preferable to pass one electrode over the paper rather than to draw the paper through between the electrodes.

Specimens. 46. The specimen shall be of relatively large area, such as a pad of tape, or a sheet from each sample of paper (see Section 2 (*a*)).

Procedure. 47. The survey shall be made by passing the specimen between the metallic electrodes at a speed of 30 to 60 ft. per minute. The voltage impressed across the electrodes shall be 100 volts per mil thickness of the specimen if alternating voltage is used, or 141 volts per mil thickness of the specimen if direct voltage is used.

NOTE 1.—If the voltage values specified above prove inconvenient of application, a lower voltage may be used, in which case it is necessary to establish a relationship between the conducting paths at this voltage and at the specified voltage. A lower value of conducting paths will be obtained at the lower voltage.

NOTE 2.—A description of equipment and a procedure which have been found suitable for making this survey of conducting paths in different thicknesses of paper appears in the Appendix.

Report. 48. The report shall include the following:

(*a*) The total number of conducting paths and the conducting paths per unit area.

(*b*) The length, width, area, and thickness of the specimen.

(*c*) The voltage applied expressed in volts, and volts per mil thickness of specimen.

(*d*) The speed of the paper.

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[1] See p. 828.

DETERIORATION

49. (*a*) *Baking Oven.*—An electrically-heated oven, equipped with an efficient means of circulating air *within* or *through* the heated chamber, and a suitable fixture upon which the paper specimens may be mounted, shall be used. In case the air is circulated *within* the body of the oven, for example by fan, it is required that the fixture upon which the specimens are mounted be a turntable rotating within the oven at a speed of about 20 r.p.m., so that the specimens shall be uniformly exposed to the oven conditions. In the case of heated air circulating *through* the oven, the fixture holding the specimens may be stationary but it is essential that it shall be mounted so as to be at least 4 in. from the oven walls at any point to permit adequate circulation in all parts of the oven, and the design should be such that there shall be an air velocity of at least one foot per second through the oven.

Apparatus.

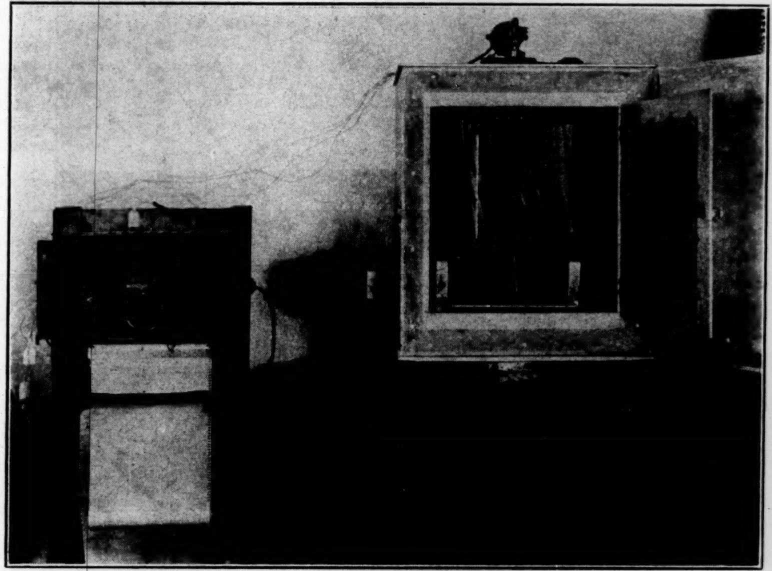

Fig. 5.—Baking Oven Equipped for Circulating Air Within the Oven.

(*b*) *Testing Equipment.*—In addition to the oven it is necessary to provide testing machines for making physical measurements on the baked specimens. The tests may be tensile breaking strength, tearing strength, folding endurance, or brittleness.[1]

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[1] The test for folding endurance does not appear in these methods but will be included as soon as the test is developed by the committee. Another sensitive test for paper deterioration is brittleness strength. This does not appear in the method, but will be included as soon as the test is developed by the committee.

Specimens. 50. (*a*) The specimens shall be at least ½ in. in width and at least 12 in. in length, and shall be cut from samples obtained in accordance with Section 2 (*a*). At least five groups of 5 specimens each shall be selected for each type of physical test noted in Section 49 (*b*). These groups of specimens shall be selected from the gross sample in some rational manner, so as to represent any known or suspected differences in the quality of the product.

Baking. 51. (*a*) The specimens shall be mounted on the fixture as shown in Figs. 5 and 6. In the case of the rotating turntable, Fig. 5, the specimens shall be mounted at such an angle that they will assist, fan-like, in stirring the air within the oven. In the case of a stationary scheme of mounting, Fig. 6, the specimens shall be mounted vertically. The rows of clips supporting the specimens, top and bottom, should be set alternately at 45-deg. angles across the oven so that the air flowing horizontally through the oven would pass between these staggered rows, turbine fashion, and assist in keeping the temperature uniform in all parts of the oven.

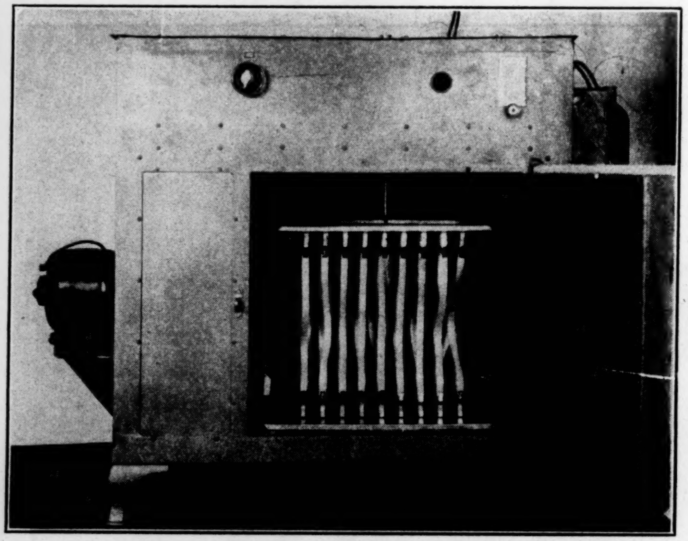

FIG. 6.—Baking Oven Equipped for Circulating Air Through the Oven.

The fixture, readily removable from the oven for mounting the specimens, shall be put in place, and the oven, previously brought to 135° C., shall be closed. Air shall be circulated, as previously indicated, and the temperature shall be maintained at 135° C. ± 2° C.

for 96 hours.[1] It is imperative that the differences in temperature in different parts of the oven shall not exceed 2° C.

Conditioning and Testing.

52. The baked specimens shall be removed from the mounting fixture, care being taken not to damage the strips, and shall be conditioned in a humidity room at 60 to 65 per cent relative humidity and at a temperature of 68 to 86° F., for a period of 4 hours. They shall then be tested in this conditioned room for tensile breaking strength, tearing strength, folding endurance, or brittleness.[2]

Report.

53. The maximum, minimum and average values shall be reported for each type of test used.

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[1] These temperature and time conditions are satisfactory for the more stable types of cable insulating papers. Less severe conditions should be used for other insulating papers and these will be included as soon as they are developed by the committee.

[2] The test for folding endurance does not appear in these methods but will be included as soon as the test is developed by the committee. Another sensitive test for paper deterioration is brittleness strength. This does not appear in the method, but will be included as soon as the test is developed by the committee.

APPENDIX

DESCRIPTION OF APPARATUS FOR A SURVEY FOR CONDUCTING PATHS IN UNTREATED INSULATING PAPERS

Equipment and procedure which have been found to be suitable for making the survey of conducting paths for different thicknesses of paper are as follows:

For Paper Having a Thickness of 0.038 mm. (0.0015 in.) or Under.—For paper having a thickness of 0.038 mm. (0.0015 in.) or under, a brass plate, a brass roller with an insulated handle, a pair of telephone receivers having a total resistance of 3000 ohms, a resistor of 80,000 ohms, and a source of direct voltage of 110 volts is used in this test. The brass plate is 31.8 cm. (12.5 in.) in width and 38.7 cm. (15.25 in.) in length and is machined and polished until its surface is level and smooth. The brass roller has a diameter of 5.08 cm. (2 in.) and a face of 2.54 cm. (1.00 in.) in width. The surface of the roller should be accurately cylindrical and polished so that it will always make a line contact when it is rolled over the brass plate in any direction. A brass plate which will warp the least is best obtained by casting a plate at least 2.54 cm. (1.00 in.) in thickness and dressing down the surface to the desired smoothness.

The size of the specimen is 38.7 cm. (15.25 in.) square, and is prepared for test as follows: Using a soft pencil (No. 2) and bearing lightly, mark off 12 swaths on each specimen (see Fig. A1). Each swath is 2.54 cm. (1 in.) in width and 30 cm. (12 in.) in length. The swaths are spaced 0.63 cm. (0.25 in.) from each other. The specimen is then placed on the brass plate in such a manner that the ends of all the swaths are spaced 0.63 cm. (0.25 in.) from the edges of the brass plate. The specimen may be held in position by means of two weights as shown in Fig. A1.

Connect the brass roller to one pole of the 110-volt circuit. Connect the brass plate, the 80,000-ohm resistance and the telephone receivers in series to the other pole of the 110-volt circuit. (See Fig. A1.) Run the brass roller once over each swath slowly in succession and count the clicks audible in the telephone receivers. Each click is considered to represent a conducting path. The total number of clicks counted on all the specimens divided by the total area of all the swaths of all the specimens, is the number of conducting paths per unit area.

For Paper Having a Thickness Greater Than 0.038 mm. (0.0015 in.) and Less Than 0.76 mm. (0.030 in.).—For paper having a thickness greater than 0.038 mm. (0.0015 in.) and less than 0.76 mm. (0.030 in.) a transformer with regulating equipment to give the required voltage, a voltmeter, a source of alternating voltage, a brass plate and a set of brass rollers are used. The brass plate is 15.2 cm. (6 in.) in width and 122 cm. (48 in.) in length and is machined and polished until its surface is level and smooth. Each brass roller has a diameter of 3.81 cm. (1.5 in.) and a face 2.54 cm. (1 in.) in width. The surface of each brass roller is accurately cylindrical and polished so that it makes a line contact when it is placed in its position on the brass plate. The brass rollers are mounted in two parallel rows above the brass plate in such a manner as to permit each individual roller to be raised away from the brass plate or lowered to make a line contact with it. The rollers in each row are spaced and have a common geometric axis. The axes of the two rows of rollers are parallel to each other and also to the long edges of the brass plate. The rollers in one row are staggered with respect to the rollers in the other row so that the surface of paper passing under the first row of rollers will be partially overlapped by the second row of rollers (see Fig. A2). The entire surface of the paper makes contact with the rollers at least once and a part of the surface of the paper will make contact twice. The rollers and plate are adequately insulated from each other.

The specimen is 7.61 meters (25 ft.) in length. Place the specimen between the brass plate and the brass rollers. During the test period the moisture content of the specimen shall not exceed 7 per cent. Lower the brass rollers to make contact with the specimen. Before connecting the transformer to the source of alternating voltage, connect the brass plate to one of the high-voltage terminals of the transformer, and the brass rollers, in multiple, to the other high-voltage terminal of the transformer. Then connect the low-voltage side of the transformer with its regulating equipment to the source of alternating voltage. Adjust the voltage between the brass plate and the brass rollers to the required value (100 volts per mil thickness of the specimen). Pass the specimen along between the rollers and the plate at a speed not to exceed 9.75 m. (32 ft.) per minute and count the number of holes burned in the specimen. Each hole shall be considered as representing a conducting path. The total number of holes counted in all the specimens divided by the total area covered (one side only) of all the specimens is the number of conducting paths per unit area.

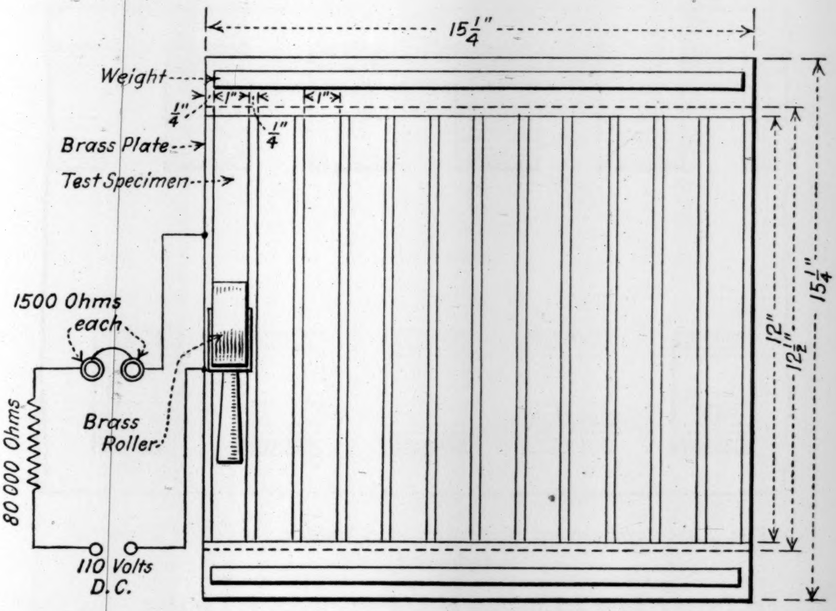


FIG. A1.—Arrangement of Apparatus for Surveying Thin Paper for Conducting Paths.

NOTE.—*Caution:* Disconnect the transformer from the source of alternating voltage before proceeding to place the next specimen between the brass plate and brass rollers.

Specimens in the form of pads of tape may be conveniently tested with an apparatus somewhat similar to the above wherein the pad is mounted on a suitable drum and the entire length of the paper in the pad rerolled on to a second drum, the paper meanwhile passing between two cylindrical rollers across which voltage is applied. The lower roller is somewhat wider than the tape and the upper roller somewhat narrower to prevent arcing through the air between the rollers. The conducting paths are counted by means of a relay and mechanical counter.

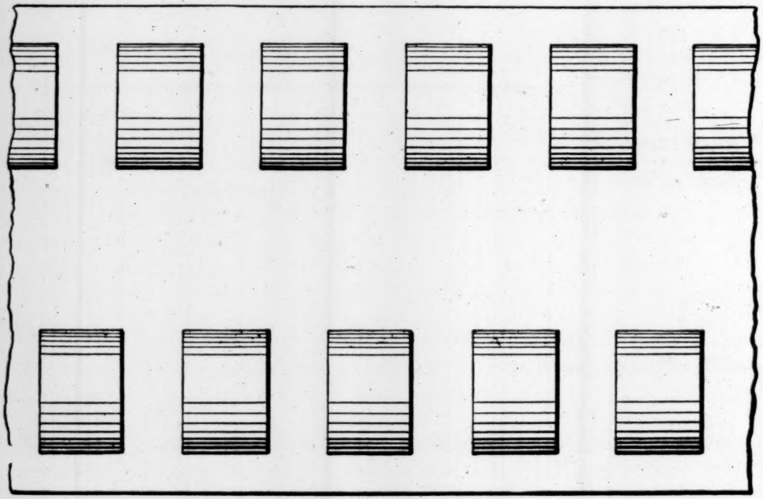
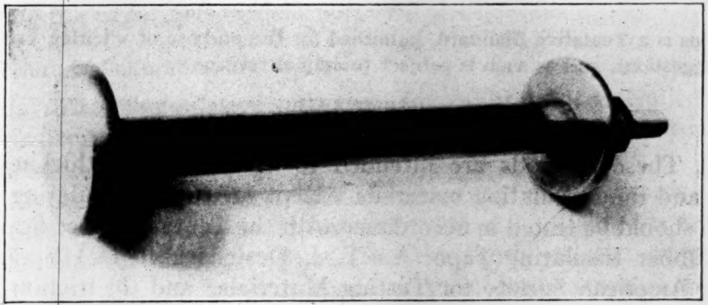
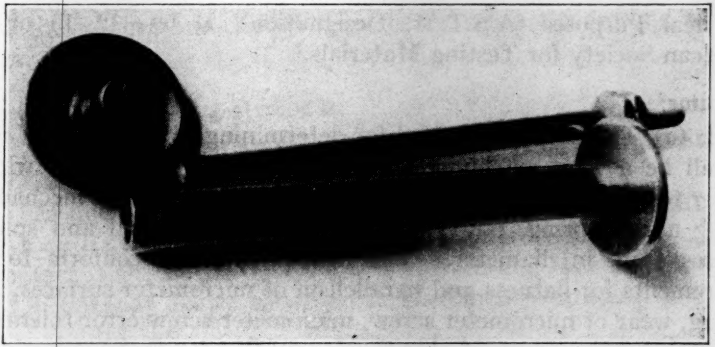


FIG. A2.—Arrangement of Brass Rollers Used in Surveying Paper for Conducting Paths.

For Paper Having a Thickness of 0.76 mm. (0.030 in.) or Over.—For paper having a thickness of 0.76 mm. (0.030 in.) or over a transformer with regulating equipment to give the required voltage, a voltmeter, a source of alternating voltage, a brass plate and a set of disc electrodes are used. The brass plate is 20.3 cm. (8 in.) in width and 122 cm. (48 in.) in length and is machined and polished until its surface is level and smooth. The contact surface of the disc electrodes has a diameter of 3.81 cm. (1.5 in.) with edges rounded to a curvature of 0.64 cm. (0.25 in.) radius. Figure A3 (*a*) shows a convenient design and Fig. A3 (*b*) shows the parts unassembled. The contact surface of each electrode is machined and polished until it is level and smooth and makes an accurate surface contact when it is placed in its position on the brass plate. The disk electrodes are mounted in four parallel rows above the brass plate in such a manner as to permit each individual electrode to be raised away from the brass plate or lowered to make an accurate surface contact with the plate. The four rows of electrodes are parallel to the long edges of the brass plate. The electrodes in one row are staggered with respect to the electrodes in each of the other rows so that the surface of a sheet of paper passing under the electrodes of the first row will be partially overlapped by the electrodes in the second row. Likewise, the surface of paper passing under the electrodes of the second row will be partially overlapped by the electrodes in the third row. And finally, the surface of paper passing under the electrodes of the first and third rows will be partially overlapped by the electrodes in the fourth row. When a sheet of paper has been passed under these four rows of electrodes, the entire surface of the paper will have made contact with the electrodes at least once and a part of the paper surface will have made contact twice. The electrodes and the brass plate should be adequately insulated from each other.



(*a*) **Assembled.**



(*b*) **Unassembled.**

FIG. A3.—Disk Electrode for Surveying Paper Over 0.76 mm. in Thickness for Conducting Paths.

The specimen is 7.61 meters (25 ft.) in length. Place the specimen between the disk electrodes and the brass plate. Lower the electrodes to make contact with the specimen, and then proceed as described above for paper 0.038 mm. (0.0015 in.) to 0.76 mm. (0.030 in.) in thickness, except that the specimen is passed between the electrodes and the brass plate at a speed not to exceed 11 m. (36 ft.) per minute. The voltage between the plate and the electrodes should be 100 volts per mil thickness of the specimen.

TENTATIVE METHODS OF TESTING SHEET AND TAPE ELECTRICAL INSULATION FOR THICKNESS[1]

A.S.T.M. Designation: D 374 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1933.

Scope

1. These methods are intended to determine the thickness of sheet and tape insulating materials, except (*a*) rubber insulating tape which should be tested in accordance with the Tentative Specifications for Rubber Insulating Tape (A.S.T.M. Designation: D 119 - 32 T) of the American Society for Testing Materials,[2] and (*b*) friction tape for electrical purposes which should be tested in accordance with the Tentative Specifications for Friction Tape for General Use for Electrical Purposes (A.S.T.M. Designation: D 69 - 32 T) of the American Society for Testing Materials.[2]

Apparatus

2. (*a*) The instrument used for determining thickness by *Method A* shall be a 1-in. machinist's type micrometer constructed with a vernier reading to 0.1 mil (0.0001 in.) and with a ratchet mechanism having a coil spring, pin-type pawl, and having anvil and spindle surfaces $\frac{1}{4}$ in. in diameter. The instrument shall conform to the requirements for flatness and parallelism of micrometer surfaces, zero reading, wear of micrometer screw, micrometer screw error tolerances and ratchet pressure specified in Section 3 (*d*), (*e*), (*f*), (*g*), (*h*) and (*i*). The micrometer shall be tested and calibrated periodically for conformity to these requirements.

(*b*) The instrument used for determining the thickness by *Method B* shall be a 1-in. machinist's type micrometer equipped with vernier but without a ratchet device and shall have anvil and spindle surfaces $\frac{1}{4}$ in. in diameter. The instrument shall conform to the requirements for flatness and parallelism of micrometer surfaces, zero reading, and micrometer screw error tolerances specified in Section 3 (*d*), (*e*), (*f*) and (*h*). The micrometer shall be tested and calibrated periodically for conformity to these requirements.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. J. A. Scott, Secretary of Committee D-9 on Electrical Insulating Materials, General Electric Co., Schenectady, N. Y.

[2] *Proceedings,* Am. Soc. Testing Mats., Vol. 32, Part I, pp. 930, 926 (1932); also 1933 Book of A.S.T.M. Tentative Standards, pp. 893, 889.

Cleaning Micrometer Surfaces

3. (*a*) Before and during instrument calibration and thickness measurements, the micrometer surfaces shall be maintained in a clean condition by lightly closing them on a clean sheet of bond paper and moving the paper between the surfaces.

Procedure in Calibrating Method A

(*b*) The manipulative procedure for calibrating controlled pressure instruments used in *Method A*, shall be in accordance with the following:

The micrometer shall be closed on the gage or calibrating device and then opened 4 or 5 mils (0.004 or 0.005 in.). Using the ratchet, the micrometer shall be again closed so slowly on the calibrating device that the mil scale divisions may be easily counted as they move past the reference mark, or at the rate of about 2 mils (0.002 in.) per second. The closing motion shall be continued at the same rate until the ratchet has clicked three times, when the reading shall be taken.

Procedure in Calibrating Method B

(*c*) The manipulative procedure for calibrating instruments used in *Method B* shall be in accordance with the following:

The micrometer shall be slowly closed on the gage or calibrating device until contact of the surfaces and gage is made. The criterion of contact is the initial development of frictional resistance to movement of the gage device between the micrometer surfaces.

Flatness of Micrometer Surfaces

(*d*) The anvil and spindle surfaces of the micrometer shall be flat to within 0.00005 in. The flatness may be determined by use of an optical flat, as follows:

After cleaning the surfaces of the flat and the micrometer (Paragraph (*a*)) the latter shall be closed on the flat as described in Paragraph (*b*) or (*c*). When illuminated by diffused daylight, interference bands are formed between the surfaces of the flat and those of the micrometer. The location, shape and number of these bands indicates the deviation from flatness in increments of half the average of the wave lengths of white light, which is taken as 0.00001 in.

A *flat surface* forms straight, parallel and equidistant fringes.

A *grooved surface* forms straight parallel fringes at unequal intervals. The estimated maximum displacement of any line from its normal position, where all lines would be equidistant, is a measure of deviation from flatness.

A *symmetrical concave or convex surface* forms concentric circular fringes, and their number is a measure of deviation from flatness.

An *unsymmetrical concave or convex surface* forms a series of curved fringes, cutting the periphery of the micrometer surface. The number of fringes cut by a straight line connecting the termini of any fringe is a measure of the deviation from flatness.

Parallelism of Micrometer Surfaces

(*e*) The anvil and spindle surfaces of the micrometer shall be parallel to each other to within 0.0001 in. when tested with a pair of screw-thread-pitch wires whose diameters, accurate to 0.00002 in., differ by an amount approximately equal to the axial movement of the spindle when rotated through 180 deg. (12.5 mils in the 1-in. micrometer). The micrometer shall be closed on the wire according to the procedure described in Paragraph (*b*) or (*c*). Observations, made with either wire placed at any location between the surfaces shall show differences of less than 0.0001 in.

Zero Reading

(*f*) The position of the anvil shall be such that a zero reading is obtained when the micrometer is closed on the anvil as described in Paragraph (*b*) or (*c*). Ten trials shall give ten readings of zero.

Wear of Micrometer Screw

(*g*) The device for compensating for wear of the micrometer screw shall be adjusted so that the spindle has no perceptible lateral or longitudinal looseness and yet may be rotated with a torque load of not more than $\frac{1}{4}$ in.-oz.

Micrometer Screw Error

(*h*) The micrometer screw error, after zero adjustment is made, shall be checked at 2, 5, and 10 mils, and at intervals of 100 mils over the remaining graduated scale. For checks up to and including a thickness of 10 mils, selected gage blades the thicknesses of which are known to ±0.00002 in. shall be used. Checks at values greater than 10 mils shall be made with standard gage blocks. Three times the standard deviation for ten readings at each setting shall not exceed 0.1 mil (0.0001 in.). Manipulation of the instrument in these checks shall be in accordance with Paragraph (*b*) or (*c*).

Ratchet Pressure

(*i*) The ratchet shall be so adjusted that a pressure of not more than 27 nor less than 23 lb. per sq. in. is developed when the spindle surface is contacted with a polished steel surface as described in Paragraph (*b*).

Method A

Method A

4. Method A is suitable for determining the thickness of papers which must be held to very close tolerances. The instrument used shall conform to the requirements specified in Section 2 (*a*).

Before starting measurements of thickness the micrometer shall be closed on the specimen at a location outside the area to be measured. The micrometer shall then be opened not more than 4 or 5 mils (0.004 or 0.005 in.) and then moved into the area selected for measurement. Using the ratchet, the micrometer surfaces shall be closed so slowly on the specimen that the mil scale divisions may be easily counted as they move past the reference mark, or at a rate of about 2 mils (0.002 in.) per second. The closing motion shall be continued at the same rate until the ratchet has clicked three times, and then the thickness shall be read by means of the vernier.

In moving from one measurement location to another this operation shall be repeated, never opening the micrometer more than 4 or 5 mils (0.004 or 0.005 in.) more than the specimen thickness.

Method B

Method B

5. Thickness measurements on papers, the acceptable tolerances of which may be wider than those requiring the use of Method A, shall be made according to Method B, as follows:

In the determination of thickness the micrometer specified in Section 2 (*b*) shall be slowly closed on the specimen until contact is made, without appreciable distortion of the specimen. The criterion of contact is the initial development of frictional resistance to movement of the specimen between the micrometer surfaces. The thickness shall then be read by means of the vernier.

In moving from one measurement location to another this operation shall be repeated, never opening the micrometer more than 4 or 5 mils (0.004 or 0.005 in.) more than the specimen thickness.

TENTATIVE METHODS OF TESTING VARNISHED CLOTHS AND VARNISHED CLOTH TAPES USED IN ELECTRICAL INSULATION[1]

A.S.T.M. Designation: D 295 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1928; REVISED, 1929, 1932, 1933.

Scope

1. These methods are intended to apply to varnished cloths and varnished cloth tapes to be used as electrical insulation and are directly applicable to both the "straight-cut" and "bias-cut" materials, unless otherwise stated in the method.

SAMPLING

Selecting Rolls

2. (*a*) Shipments of varnished cloth and varnished cloth tapes shall be sampled as specified in Paragraphs (*b*) and (*c*). The rolls or pads shall be selected in such a manner as to be representative of the shipment.

(*b*) *Cloth.*—One roll shall be selected from each ten rolls in a shipment of full-width varnished cloth. The minimum number of rolls selected from any shipment shall be two.

(*c*) *Tape.*—At least one roll or pad shall be selected from each 1000 rolls or pads in a shipment of varnished cloth tape. The minimum number of rolls or pads selected from any shipment shall be ten.

Selecting Samples

3. (*a*) Except for tape shipped packed in oil, not less than two turns of cloth or six turns of tape from each roll or pad selected for sampling shall be torn off and discarded before the samples are selected. The number of samples required for purposes of test shall then be cut across the entire width of each roll or pad. The length of the samples shall not be less than 91.44 cm. (36 in.) for straight-cut material; from seam to seam for sewed bias-cut material; and from jointed-selvage to jointed-selvage for seamless bias-cut material.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. J. A. Scott, Secretary of Committee D-9 on Electrical Insulating Materials, General Electric Co., Schenectady, N. Y.

NOTE 1.—Specimens of bias-cut materials cut from the above samples shall exclude seams and jointed-selvages from the test areas.

NOTE 2.—If it is desired to test the seams or jointed-selvages for tensile breaking strength, additional specimens will have to be cut so that the seams or jointed-selvages are in the center of the specimens.

(*b*) From shipments such as sheets of cloth or strips of tape, the samples shall be representative of the shipment and shall be taken in accordance with Paragraph (*a*).

CONDITIONING

Conditioning

4. All specimens shall be taken from the samples selected in accordance with Section 3 and before testing shall be temperature conditioned for at least two hours in air maintained at a temperature between the limits of 20 and 30 C. (68 and 86 F.).

THICKNESS

Apparatus

5. The thickness shall be measured with a machinist's micrometer graduated to 0.001 in. and having anvil and spindle surfaces not less than 0.24 in. nor more than 0.26 in. in diameter.

NOTE.—The micrometers specified in the Tentative Methods of Testing Sheet and Tape Electrical Insulation for Thickness (A.S.T.M. Designation: D 374 - 33 T) of the American Society for Testing Materials,[1] are suitable for this purpose.

Specimens

6. Specimens for test shall consist of samples selected in accordance with Section 3.

Procedure

7. In making thickness measurements, only one layer of material shall be used.

Number of Measurements

8. (*a*) In the case of cloths, ten measurements equally spaced across the width of the specimen shall be taken and the thickness of the cloth shall be the average of the ten measurements.

(*b*) In the case of tapes, unless otherwise specified, ten measurements equally spaced along the length of each specimen shall be taken and the thickness of the tape shall be the average of the ten measurements.

NOTE.—The average thickness, as obtained in Section 15 for the dielectric strength test, may be conveniently used instead of the separate test described above.

Report

9. The report shall include the average, maximum, and minimum thicknesses in inches.

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[1] See p. 860.

TENSILE BREAKING STRENGTH

Apparatus

10. (*a*) A testing machine[1] of the dead-weight pendulum type shall be used. The machine shall preferably be power driven.

(*b*) The capacity of the machine shall not exceed 113 kg. (250 lb.).

(*c*) The machine shall be graduated to read 1 lb. or 1 kg. or less per scale division for testing specimens breaking at 22.7 kg. (50 lb.) or over, and to 0.5 lb. or 0.5 kg. or less for testing specimens breaking under 22.7 kg. (50 lb.).

Test Specimens

11. Specimens cut from the full width cloth or from tapes over 2.54 cm. (1 in.) in width shall be 2.54 cm. (1 in.) in width and not less than 35.54 cm. (14 in.) in length. For tape having a nominal width of 2.54 cm. (1 in.) or under the specimens shall be of the original width and shall be not less than 35.54 cm. (14 in.) in length.

NOTE.—If it is desired to test the seams or jointed-selvages of bias-cut materials for tensile breaking strength, specimens obtained as described in Note 2 to Section 3 (*a*) shall be clamped in the testing machine so that the seams or jointed-selvages are midway between the two jaws. When testing, all readings obtained when the specimen breaks away from the seam or jointed-selvage shall be rejected.

Number of Specimens

12. (*a*) In the case of straight-cut cloths, ten specimens shall be cut in the direction of the warp threads and ten in the direction of the filling threads from samples selected in accordance with Section 3.

(*b*) In the case of bias-cut cloths, ten specimens shall be cut in the direction of the length from samples selected in accordance with Section 3.

(*c*) In the case of tapes, one specimen shall be cut from each roll selected in accordance with Section 2 (*c*).

Procedure

13. (*a*) The ratio of the clearance distance between jaws to the width of the specimen shall not be less than 5 to 1 nor more than 10 to 1.

(*b*) The rate of travel of the movable jaw shall be constant and preferably 30.5 cm. (12 in.) per minute, but it may be within the limits of 28 cm. (11 in.) and 33 cm. (13 in.) per minute provided it is constant.

(*c*) All readings obtained when the specimen breaks at or in the jaws shall be rejected.

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[1] This apparatus is the same as that used for the testing of paper and described in Section 12 of the Tentative Methods of Testing Untreated Paper Used in Electrical Insulation (A.S.T.M. Designation: D 202 – 33 T), see p. 841.

Report

14. (*a*) The tensile breaking strength of a roll shall be the average of the breaking loads of all the specimens from the roll. The report shall include the average, maximum, and minimum breaking loads in kilograms or pounds together with the width of the specimens and the nominal thickness.

(*b*) In the case of straight-cut cloths, the tensile breaking strength of the warp threads and the filling threads shall be reported separately.

DIELECTRIC STRENGTH

Method

15. The dielectric strength shall be determined in accordance with the Tentative Methods of Testing Sheet and Tape Insulating Materials for Dielectric Strength (A.S.T.M. Designation: D 149 - 33 T) of the American Society for Testing Materials,[1] except that the voltage on the specimen shall in all cases be increased at the uniform rate of 0.5 kv. per second up to breakdown.

Specimens

16. (*a*) In the case of cloths, a specimen at least 10.16 cm. (4 in.) in width shall be cut diagonally from corner to corner from a sample selected in accordance with Section 3.

(*b*) In the case of tapes, the specimens shall be samples selected in accordance with Section 3.

ELONGATION

(In the Case of Bias-Cut Material)

Scope

17. This method is intended to determine the effect of mechanical tension on bias-cut varnished cloths and tapes. This test is not applicable to tapes of less than 1.27 cm. (0.5 in.) in nominal width.

Apparatus

18. The apparatus required for the test shall consist of a pair of clamps for gripping the ends of the specimen. The clamps shall not be less than 5.08 cm. (2.0 in.) in width and one shall be provided with means for attaching to a fixed support and the other with means for affixing suspended weights. See Fig. 1 for suggested form of clamp.

Specimens

19. (*a*) In the case of bias-cut cloths, specimens shall be cut in the direction of the length from the samples selected in accordance with Section 3. They shall not exceed 3.81 cm. (1.5 in.) in width and shall be at least 91.44 cm. (36 in.) in length.

(*b*) In the case of bias-cut tapes, specimens shall be samples selected in accordance with Section 3 and they shall not exceed 3.81

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[1] See p. 828.

cm. (1.5 in.) in width. Tapes of greater width than this shall be cut to 3.81 cm. (1.5 in.) or less before testing.

NOTE.—Strips of "Scotch tape" make a satisfactory method for marking the gage length on the elongation test specimens.

Procedure

20. (*a*) *Elongation.*—A gage length, L, shall be marked on the test specimen and the specimen shall be fastened between the two clamps so that the test length is centrally located between the clamps. The gage length, L, shall be determined from the ratio:

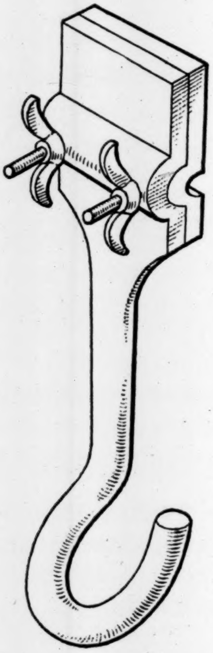

FIG. 1.—Clamp for Elongation Test.

$$\frac{L}{W} = 10$$

where W is the width of the specimen.

The clearance distance, D, between the jaws of the clamps shall be determined from the ratio:

$$\frac{D}{W} = 22$$

The test specimen shall be weighted with a specified load, M

(including the weight of the clamp), and at the end of 35 minutes the distance between gage lines, L_1, shall be determined and the load then removed.

The percentage elongation shall be calculated from the following formula:

$$\text{Elongation, per cent} = \frac{L_1 - L}{L} \times 100$$

where L = the original gage length, in millimeters or inches; and

L_1 = the distance between gage lines under load (maximum elongation), in millimeters or inches.

(*b*) *Dielectric Strength.*—After at least 20 minutes following the removal of the load, five puncturing voltages shall be taken within the gage length of the specimen in accordance with Method *A* for Short-Time Dielectric Strength Test as described in Sections 2 to 12, inclusive, of the Tentative Methods of Testing Sheet and Tape Insulating Materials for Dielectric Strength (A.S.T.M. Designation: D 149 - 33 T) of the American Society for Testing Materials.[1]

Report

21. The report shall include the following:

(*a*) the load in pounds per inch width of tape;

(*b*) the percentage elongation;

(*c*) the average dielectric strength in volts per mil after elongation; and

(*d*) the temperature of the room during the elongation test.

RESISTANCE TO OIL

Procedure

22. One specimen, 30.48 cm. (12.0 in.) in length, and not exceeding 3.81 cm. (1.5 in.) in width shall be cut from each of the rolls selected in accordance with Section 2, and immersed for 15 minutes in a specified oil, maintained at a temperature of from 97 to 103 C. At the end of this time the specimens shall be removed from the oil, allowed to cool for 30 minutes to room temperature and any excess oil removed by placing between blotters without any sliding.

Examination

23. The varnish film shall neither disintegrate in the oil nor flake either in the oil or on the blotter. Disintegration in the oil may be detected by examination of the used oil for "turbidness."

NOTE.—The oil may be considered "turbid" if a sample of used oil filtered through filter paper can be distinguished from an unfiltered sample of the used oil when the two samples, in identical containers, are held in front of a diffused light.

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[1] See p. 828.

Report

24. The specimen shall be reported as passing the test when it shows no evidence of disintegration when examined in accordance with Section 23.

WEIGHT

Weight

25. Specimens of sufficient size to weigh not less than 5 g. (0.18 oz.) shall be accurately weighed on an analytical balance and the weight shall be reported on some commercial unit basis such as, the weight per square yard, the weight per gross yard per 1 in. in width, or the weight per roll.

THREADS PER INCH

Count

26. The count or threads per inch of the varnished cloth or varnished cloth tape shall be determined separately on the warp and filling by counting a space of not less than 1 in. (2.54 cm.) in at least five different places in the sample strip (or strips). The average of the five determinations shall be the count.

Report

27. The results of the warp count and the filling count shall be reported separately as threads per inch.

NOTE 1.—The warp threads in straight-cut materials are the threads which are parallel with the length dimension, while in bias-cut materials the warp threads are parallel with the seams and jointed-selvages.

NOTE 2.—Before counting black, varnished materials it will be necessary to remove the varnish film with a knife blade or other suitable instrument. Liquid varnish removers are unsuitable for this purpose as they cause a swelling of the fibers and a shrinkage of cloth with a consequent increase in threads per inch; therefore, the films must be removed mechanically.

TENTATIVE SPECIFICATIONS
FOR
INSULATED WIRE AND CABLE: 30 PER CENT HEVEA RUBBER[1]

A.S.T.M. Designation: D 27 - 33 T

This is a Tentative Standard, published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1916; REVISED, 1921, 1928, 1931, 1933.[2]

Scope

1. These specifications cover conductors, rubber insulation, cable tape, cotton braid and lead sheaths. The design and factor of safety depend upon the service conditions and shall be at the option of the purchaser.

(*A*) CONDUCTOR

MANUFACTURE

Material

2. The conductor shall be of soft annealed copper, properly tinned, and have the properties and characteristics herein required.

Strand

3. Each individual wire of a stranded conductor shall be considered separately and shall be designated as a strand.

Shape

4. Each solid conductor and each strand shall be round and reasonably free from imperfections.

Stranding

5. The stranding shall conform to the requirements of Table I and shall be either standard concentric or flexible as specified in the order.

Density

6. For the purpose of calculating weights, cross-sections, etc., in conductivity determinations, the density of copper shall be taken as 8.89 g. per cu. cm. (See Appendix.)

PERMISSIBLE VARIATIONS IN DIMENSIONS

Diameter and Area

7. (*a*) *Permissible Variation.*—When the diameter of solid conductors and strands is specified, the permissible variation from the

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Arthur W. Carpenter, Secretary of Committee D-11 on Rubber Products, The B. F. Goodrich Co., Akron, Ohio.

[2] Latest revision accepted by Committee E-10 on Standards, August 16, 1933.

specified value shall not exceed 1 per cent under or 2 per cent over for wire 0.02 in. in diameter and larger, and 0.1 mil under for wire less than 0.02 in. in diameter.

NOTE.—These limits differ from those in the Standard Specifications for Tinned Soft or Annealed Copper Wire for Rubber Insulation (A.S.T.M. Designation: B 33) of the American Society for Testing Materials[1] because of the additional manipulation to which the wire is subjected subsequent to the stage where Specifications B 33 apply.

When the area of cross-section of cables is specified, the permissible variation shall not exceed 1 per cent under the specified value.

(*b*) *Method of Gaging Diameter.*—When wire is submitted in coils, each coil shall be gaged in three places, one near each end and one approximately at the middle. When wire is submitted on spools or reels, approximately 12 ft. of the wire shall be reeled off and the wire then gaged in six places between the second foot and the twelfth foot from the end.

TABLE I.—STRANDING OF INSULATED CONDUCTORS.

For intermediate sizes use stranding for next larger size.

Conductors of No. 0000 and smaller are often made solid and this table of stranding should not be interpreted as excluding such practice.

In assembly column, "37 by 19 rope lay," signifies 37 strands of 19 wires assembled like a rope.

Size of Conductors	Standard Concentric Stranding,[a] Number of Wires	Flexible Stranding	
		Number of Wires	Assembly
2 000 000 cir. mils	127	703	37 by 19 rope lay
1 500 000 cir. mils	91	703	37 by 19 rope lay
1 000 000 cir. mils	61	427	61 by 7 rope lay
500 000 cir. mils	37	427	61 by 7 rope lay
300 000 cir. mils	37	259	37 by 7 rope lay
0 000 A. w. g	19	133	19 by 7 rope lay
1 A. w. g	19	91	Concentric
2 A. w. g	7	91	Concentric
4 A. w. g	7	61	Concentric
10 A. w. g	7	37	Concentric
16 A. w. g	7	26	Bunched
18 A. w. g	7	16	Bunched
20 A. w. g	7	10	Bunched

[a] The standard concentric stranding in this table agrees with Table XII of *Circular No. 31*, "Copper Wire and Cables," U. S. Bureau of Standards; and also Table II of Standard No. 30 "Wires and Cables" of the American Institute of Electrical Engineers.

(*c*) *Calculation of Area.*—The area of cross-section of wire shall be calculated from the average of the measurements of the diameter made in accordance with Paragraph (*b*). The area of cross-section of cable shall be considered to be the sum of the cross-sectional areas of its component wires, when laid out straight and measured perpendicular to their axes.

(*d*) *Rejection.*—A coil or reel shall be rejected if the average diameter obtained from the measurements made in accordance with Paragraph (*b*), or the area calculated in accordance with Paragraph (*c*), is not within the limits specified in Paragraph (*a*).

A coil or reel shall be rejected if any individual measurement of diameter or of area of cross-section is not within twice the limits of Paragraph (*a*).

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[1] 1933 Book of A.S.T.M. Standards, Part I, p. 777.

PHYSICAL PROPERTIES AND TESTS

Tensile Properties

8. (*a*) Each solid conductor and each strand previous to stranding shall be so drawn and annealed that after tinning it shall conform to the values in Table II.

After stranding, the tensile strength of each strand shall not exceed that specified in Table II by more than 5 per cent and the minimum elongation in 10 in. shall not be less than that specified in Table II by more than 5 per cent.

(*b*) For nominal diameters between listed sizes the requirements shall be those of the next larger sizes indicated in Table II.

Tension Tests

9. (*a*) *Method of Test.*—Tension tests shall be made on fair samples and the elongation shall be determined as the permanent increase in length, due to the breaking of the wire in tension, measured between bench marks originally 10 in. apart. The specimen shall break between the bench marks and not closer than 1 in. to either mark.

TABLE II.—TENSILE REQUIREMENTS OF CONDUCTORS.

Size of Conductor		Maximum Tensile Strength, lb. per sq. in.	Minimum Elongation in 10 in., per cent
Diameter, in.	A.w.g. Number		
0.460 to 0.290	0000 to 1	36 000	30
0.289 to 0.103	2 to 10	37 000	25
0.102 to 0.021	12 to 24	38 500	20
0.020 to 0.012	25 to 28	39 000	15
0.011 to 0.003	29 to 40	40 000	10

(*b*) *Number of Tests.*—Samples shall be taken in accordance with Section 25.

(*c*) *Retests and Rejections.*—If upon testing a sample from a coil, reel or spool of wire, the results are found to be above the stated value for tensile strength or below the stated value for elongation, tests upon two additional samples will be made and the average of the three tests shall determine acceptance or rejection.

Conductivity

10. The conductivity of the conductors after tinning shall be not less than that specified in Table III.

TABLE III.—CONDUCTIVITY REQUIREMENTS.

DIAMETER, IN.	A.W.G. NUMBER	CONDUCTIVITY, PER CENT
0.460 to 0.290	0000 to 1	97.65
0.289 to 0.103	2 to 10	97.15
0.102 to 0.021	12 to 24	96.15
0.020 to 0.012	25 to 28	94.15
0.011 to 0.003	29 to 40	93.15

NOTE.—The above values for conductivity conform to the International Annealed Copper Standard. (See Appendix, p. 892.)

Tinning Test

11. (*a*) The continuity of the tin coating of each sample before stranding or insulating shall be determined by the sodium polysulfide test which shall be made in accordance with the requirements of Sections 4 to 10, inclusive, of the Standard Specifications for Tinned Soft or Annealed Copper Wire for Rubber Insulation (A.S.T.M. Designation: B 33) of the American Society for Testing Materials.[1]

(*b*) *Number of Tests.*—Samples shall be taken in accordance with Section 25.

(*c*) *Retests and Rejections.*—If the specimens tested in accordance with Paragraph (*a*) shows any signs of blackening, two more specimens shall be tested. If one of these two additional specimens shows any blackening, that coil or reel shall be rejected. If both specimens are free from any signs of blackening, the coil or reel shall be accepted. If more than 10 per cent of the samples in the entire order fail, all of the wire shall be rejected. If 10 per cent or less of the samples in the entire lot fail, each coil, reel or length may be tested and accepted or rejected upon the results of the individual tests.

(*B*) INSULATION

Workmanship

12. (*a*) The insulation shall be of either Class A or Class AO rubber compound as specified in the order. Where neither class is specified, the manufacturer may supply either class.

(*b*) The insulation shall consist of a properly vulcanized rubber compound which shall be homogeneous in character, tough, elastic and applied concentrically about the conductor and shall fit tightly thereto. Where the insulation is applied in more than one layer, adjacent layers shall be vulcanized into a homogeneous mass.

(*c*) The insulation of wires up to No. 7 A.w.g., inclusive, shall be covered with a single cotton braid. On larger sizes the fibrous covering shall consist of a cable tape and a cotton braid or two cotton braids. The tape shall conform to the requirements specified in Sections 47 to 50, inclusive. The cotton braid shall be applied in accordance with Sections 51 to 55, inclusive, and shall be finished in accordance with Sections 56 and 57.

(*d*) Where repairs or joints are made in the insulation, the work shall be done in such manner that the repaired part of the joint, and all parts affected in the process, shall be as strong and durable electrically and mechanically as the remainder of the insulation and shall not exceed the limitations on the thickness specified in Section 17.

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[1] 1933 Book of A.S.T.M. Standards, Part I, p. 777.

MANUFACTURE

Composition

13. (a) The insulation shall consist of either Class A or Class AO rubber compound.

Class A rubber compound shall contain exclusively not less than 30 per cent nor more than 33 per cent of the best quality Hevea rubber which has not previously been used in a rubber compound, solid waxy hydrocarbons, suitable mineral matter and sufficient sulfur to properly vulcanize the compound.

Class AO rubber compound shall contain the same ingredients as Class A with the addition of antioxidants and organic accelerators.

(b) The mineral matter shall be dry and that of Class A insulation shall be free from organic materials.

(c) The waxy hydrocarbons used shall be solid at 54° C. and shall be free from saponifiable matter.

(d) Contamination of the compound, such as by the use of impregnated tapes, will not excuse the manufacturer from conforming to these specifications.

CHEMICAL PROPERTIES

Quantitative Requirements

14. The insulation after vulcanization shall conform on analysis to the following requirements expressed as percentages by weight of the whole sample:

CLASS A AND CLASS AO	MAXIMUM	MINIMUM
Rubber, per cent	33	30
Waxy hydrocarbons, per cent	4	..
Free sulfur, per cent	0.7	..

	30 PER CENT RUBBER[a]		33 PER CENT RUBBER[a]	
	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM
Saponifiable acetone extract, per cent:				
Class A	1.35	0.55	1.50	0.60
Class AO	2.00	....	2.20	....
Unsaponifiable resins, per cent:				
Class A	0.45	....	0.50	....
Class AO	1.00	....	1.10	....
Chloroform extract, per cent:				
Classes A and AO	0.90	....	1.00	....
Alcoholic potash extract, per cent:				
Classes A and AO	0.55	....	0.60	....
Total sulfur, per cent:				
Classes A and AO	2.10	....	2.30	....

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[a] For percentages between 30 and 33, the limits shall be in proportion to the percentage of rubber found.

Qualitative Requirements

15. (*a*) The acetone solution from either compound shall not fluoresce and the acetone extract (60 ml.) from Class A compound shall not be darker than a light straw color.

(*b*) The hydrocarbons shall be solid, waxy and not darker than a light brown.

(*c*) The chloroform extract (60 ml.) shall not be darker than a straw color.

PHYSICAL PROPERTIES

Physical Properties

16. The insulation shall conform to the following requirements as to physical properties:

		CLASS A	CLASS AO
Tensile strength, minimum, lb. per sq. in.		1000	1200
Set in 2 in. gage length, maximum, in.		3/8	3/8
Elongation at rupture in 2-in. gage length, minimum, per cent		350	400
Depreciation in tensile strength and elongation after oxygen bomb test, maximum, per cent		....	25
Depreciation in tensile strength and elongation after Geer oven test, maximum, per cent		....	15
Specific gravity, minimum	30 per cent rubber	1.75[a]	1.75[a]
	33 per cent rubber	1.67[a]	1.67[a]

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[a] For percentages between 30 and 33, the specific gravity limits shall be in proportion to the percentage of rubber found.

THICKNESS

Thickness

17. The average thickness of the insulation shall be not less than that given in Table IV. The thickness of the insulation at the thinnest part shall be not more than 10 per cent less than the specified thickness, but in no case shall such 10 per cent allowance exceed 0.031 in.

ELECTRICAL PROPERTIES

High Voltage Test

18. Each coil, reel, or length of wire or cable, after vulcanization and before the application of any covering other than tape or braid used in vulcanization shall successfully withstand the application of an alternating voltage of not less than that given in Table V for a period of 5 minutes.

Insulation Resistance

19. Each coil, reel, or length of wire or cable after being subjected to the high voltage test specified in Section 18 shall have an insulation resistance not less than that given in Table VI.

METHODS OF TESTING

CHEMICAL ANALYSIS

Sampling

20. Samples of the vulcanized rubber compound for chemical analysis shall be taken after the successful completion of the physical and electrical tests, and before applying impregnating compounds which may contaminate the rubber. The samples shall be taken at the option of the purchaser. The purchaser shall assure himself that all samples are free from contamination and change due to torch heating. Wherever practicable, samples shall be taken at a distance of at least 3 ft. from the end of the wire.

TABLE IV.—THICKNESS OF INSULATION.

Thickness in sixty-fourths of an inch

Size of Conductor		Working Pressure, Volts, Direct or Alternating Commercial Power Frequencies											
A. w. g. Numbers or Circular Mils	sq. mm.	600 or less	750	1500	2500	3500	5000	6000	7000	8000	9000	10000	11000
No. 14 to No. 9	2.08 to 6.63	3	4	6	8	10	12	..	..	..	..	..	..
No. 8 to No. 2	8.37 to 33.6	4	5	7	9	10	12	14	16	18	20	22	24
No. 1 to No. 0000	42.4 to 107	5	6	8	10	10	12	14	16	18	20	22	24
250 000 to 500 000 cir. mils	127 to 253	6	8	9	10	11	12	14	16	18	20	22	24
550 000 to 1 000 000 cir. mils	279 to 507	7	9	10	10	12	12	14	16	18	20	22	24
1 250 000 to 2 000 000 cir. mils	633 to 1013	8	10	10	10	12	14	16	18	18	20	22	24

NOTE.—The thickness of insulation (on each conductor in the case of multiple conductor cables) shall be based on the highest r. m. s. voltage between the conductor and the outside of its insulation

For an intermediate size or an intermediate working voltage the thickness shall be that for the next larger size or higher working voltage.

TABLE V.—ALTERNATING TEST VOLTAGE IN KILOVOLTS.

Size of Conductor, A. w. g. Numbers or Circular Mils	Working Pressure, Volts, Direct or Alternating Commercial Power Frequencies											
	600 or less	750	1500	2500	3500	5000	6000	7000	8000	9000	10 000	11 000
No. 14 to No. 9	3	4	6	8	10	13	..	..	..	..	..	..
No. 8 to No. 6	3.5	5	7	9	10	13	16	17	18	20	22	24
No. 5 to No. 2	3.5	5	7	9	10	13	16	19	22	25	28	31
No. 1 to No. 0000	3.5	6	8	10	10	13	16	19	22	25	28	31
250 000 to 500 000 cir. mils	4	8	9	10	11.5	13	16	19	22	25	28	31
550 000 to 1 000 000 cir. mils	4	9	10	10	13	13	16	19	22	25	28	31
1 250 000 to 2 000 000 cir. mils	4	10	10	10	13	16	19	22	22	25	28	31

NOTE.—For an intermediate size or an intermediate working voltage, the test voltage shall be that of the next larger size, or working voltage.

Procedure

21. The insulation shall be analyzed in accordance with (*B*) Complete Procedure as described in the Standard Methods of

Chemical Analysis of Rubber Products (A.S.T.M. Designation: D 297) of the American Society for Testing Materials.[1]

TABLE VI.—INSULATION RESISTANCE, MEGOHMS-1000 FT. AT 60° F. (15.5° C.).[a]

Size of Conductor, A. w. g. Numbers or Circular Mils	Thickness of Insulation in Sixty-fourths of an Inch							
	2	3	4	5	6	7	8	10
No. 18	8400	10 800	....	....	....	....	....	....
No. 16	7400	9 500	....	....	....	....	....	....
No. 14	....	8 100	9 800	11 400	12 400	13 500	14 000	16 100
No. 12	....	7 100	8 400	9 800	10 800	11 900	12 700	14 500
No. 10	....	6 050	7 150	8 400	9 500	10 600	11 400	12 700
No. 8	....	4 500	5 550	5 600	7 650	8 700	9 200	10 800
No. 6	....	....	4 500	5 550	6 350	7 150	7 650	9 200
No. 4	....	....	3 950	4 500	5 300	6 050	6 600	7 650
No. 2	....	....	3 450	3 950	4 500	5 000	5 550	6 600
No. 1	....	....	3 150	3 450	3 950	4 500	5 300	6 050
No. 0	....	....	....	3 150	3 700	4 200	5 000	5 550
No. 00	....	....	....	2 900	3 450	3 950	4 500	5 000
No. 000	....	....	....	2 650	3 150	3 450	3 950	4 500
No. 0000	....	....	....	2 400	2 900	3 150	3 450	4 200
250 000 cir. mils	....	....	....	2 100	2 500	3 050	3 300	3 850
350 000 cir. mils	....	....	....	1 850	2 250	2 500	2 750	3 550
500 000 cir. mils	....	....	....	1 600	2 000	2 100	2 500	3 050
750 000 cir. mils	....	....	....	....	....	1 700	2 100	2 500
1 000 000 cir. mils	....	....	....	....	....	1 600	1 700	2 100
1 250 000 cir. mils	....	....	....	....	....	....	1 700	2 000
1 500 000 cir. mils	....	....	....	....	....	....	1 600	1 700
1 750 000 cir. mils	....	....	....	....	....	....	1 450	1 600
2 000 000 cir. mils	....	....	....	....	....	....	1 050	1 450

Size of Conductor, A. w. g. Numbers or Circular Mils	Thickness of Insulation in Sixty-fourths of an Inch						
	12	14	16	18	20	22	24
No. 14	17 700	....	....	....	....	....	....
No. 12	15 800	....	....	....	....	....	....
No. 10	14 000	....	....	....	....	....	....
No. 8	11 600	12 700	13 700	14 500	15 300	16 100	16 600
No. 6	10 300	11 100	12 100	12 900	13 500	14 300	14 800
No. 4	8 700	9 800	10 600	11 400	11 900	12 700	13 200
No. 2	7 650	8 400	9 000	9 800	10 300	11 100	11 600
No. 1	7 150	7 650	8 400	9 200	9 800	10 300	10 800
No. 0	6 350	7 150	7 900	8 400	9 000	9 500	10 000
No. 00	5 550	6 600	7 150	7 900	8 400	9 000	9 500
No. 000	5 300	6 050	6 600	7 150	7 650	8 200	....
No. 0000	5 000	5 550	6 050	6 600	7 150	7 650	....
250 000 cir. mils	4 600	5 300	5 800	6 350	6 750	....	....
350 000 cir. mils	4 100	4 500	5 000	5 550	5 950	....	....
500 000 cir. mils	3 550	3 950	4 500	4 750	....	....	....
750 000 cir. mils	2 750	3 300	3 700	4 100	....	....	....
1 000 000 cir. mils	2 500	2 900	3 300	....	....	....	....
1 250 000 cir. mils	2 250	2 650	3 050	....	....	....	....
1 500 000 cir. mils	2 100	2 500	....	....	....	....	....
1 750 000 cir. mils	2 000	2 400	....	....	....	....	....
2 000 000 cir. mils	1 700	2 250	....	....	....	....	....

[a] This table is based on a constant, $K = 21\,120$ in the following formula:

$$R = K \log_{10} \frac{D}{d};$$ where R = resistance in megohms-1000 ft., K = constant,

D = diameter over insulation, on each conductor, and d = diameter over conductor.

NOTE.—For an intermediate size, the insulation resistance shall be that of the next larger size.

Rejection and Retests

22. The purchaser may make a chemical analysis on any one of the samples selected as described in Section 20 to determine if the

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[1] 1933 Book of A.S.T.M. Standards, Part II, p. 1130.

compound conforms to the requirements of Sections 14 and 15. Failure of any sample selected to conform to the requirements shall be sufficient cause for rejecting the wire which that sample represents, except in the case of failure to conform to the requirements for either or both free sulfur and chloroform extract. In case of such failure, the coil from which the sample was taken shall be rejected and two additional samples shall be selected from the remainder of the order. The remainder of the order shall be accepted if both samples so selected conform to the requirements for free sulfur or chloroform extract. The entire order shall be rejected if either sample fails.

SPECIFIC GRAVITY

Specific Gravity

23. The specific gravity shall be determined in accordance with Section 27 of the Standard Methods of Chemical Analysis of Rubber Products (A.S.T.M. Designation: D 297) of the American Society for Testing Materials.[1]

TENSILE STRENGTH, SET AND ELONGATION AT RUPTURE

Sampling for Tests

24. (*a*) When an order calls for less than 500 ft., physical tests may be waived at the option of the purchaser.

(*b*) When an order calls for 500 ft. or more, samples for purposes of test shall be taken from 10 per cent of the coils, reels or lengths, but in any case at least one sample shall be taken.

Test Specimen

25. (*a*) *Size.*—The test specimen may be the entire section of the insulation in the case of small wires, or, in the case of a large wire or cable, either a segment of a section cut with a sharp knife held tangentially to the conductor or a shaped specimen cut out with a standard die. The test specimen shall be as free as possible from surface incisions and imperfections. There shall be no limit to the cross-section of the test specimen, except as restricted by the capacity of the testing machine.

NOTE.—The removal of the rubber insulation can be greatly accelerated and in most cases a test specimen which is an entire section can be obtained free from surface incisions and imperfections by means of metallic mercury. The mercury should be introduced at one end of the sample between the insulation and the tinned surface of the conductor, and the sample inclined on a support with the end to which the mercury is applied at the top. The separation of the rubber insulation results from the amalgamation of the tin of the conductor with the mercury. The amalgamation is assisted by first immersing and rubbing the tinning on the exposed end of the conductor in the mercury.

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[1] 1933 Book of A.S.T.M. Standards, Part II, p. 1130.

(*b*) *Condition and Age.*—Specimens shall not be heated, immersed in water or subjected to any mechanical or chemical treatment not specifically prescribed in these specifications. Tests shall be made not earlier than 24 hours nor later than 60 days after the vulcanization unless approved by the manufacturer.

(*c*) *Buffing.*—In the event of any irregularities on the surface of the test specimen, it shall be made smooth and of uniform thickness within 5 per cent of the original thickness by buffing, except when large strands are used, in which case the rubber sample shall be buffed sufficiently to remove all corrugations.

Calculation of Area

26. Calculation of the area of the test specimens shall be made as follows:

(*a*) Where the total cross-section of the insulation is used, the area shall be taken as the difference between the area of the circle whose diameter is the minimum average outside diameter of the insulation and the area of the conductor. The area of a stranded conductor shall be calculated from its maximum diameter.

(*b*) Where a slice cut from the insulation by a knife held tangent to the wire is used, and the slice so cut has the cross-section of a segment of a circle, the area shall be calculated as that of the segment of a circle whose diameter is that of the insulation. The height of the segment is the wall of insulation on the side from which the slice is taken. (The values may be obtained from a table giving the areas of segments of a unit circle for the ratio of the height of the segment to the diameter of the circle.)

(*c*) Where the cross-section of the slice is not a segment of a circle, the area shall be calculated from a direct measurement of the volume or from the specific gravity and the weight of a known length of the specimen having a uniform cross-section.

(*d*) Where a portion of a sector of a circle has to be taken where the conductor is large and the insulation thin, the area shall be calculated as the thickness times the width. (This applies either to a straight test piece or one stamped out with a die, and assumes that corrugations have been removed by buffing.)

(*e*) Where a portion of a sector of a circle has to be taken where the conductor is large and the insulation thick, the area shall be calculated as the proportional part of the area of the total cross-section.

Temperature at Test

27. Physical tests shall be made at a room temperature not less than 65° F. (18.3° C.) nor more than 90° F. (32.2° C.) and the test specimen shall have been kept at the room temperature not less than 30 minutes prior to the test.

Tension Testing Machine

28. The tension testing machine shall be power-driven and preferably of the pendulum type. The machine shall be accurate within 1 per cent of the breaking load. A spring balance type of apparatus may be used if provided with a device which will indicate the actual maximum load at which rupture takes place and if provision is made to prevent recoil of the spring.

Tensile Strength Test Procedure

29. The tensile strength test shall be made on a specimen which has not been previously stretched. The specimen shall have a length of not less than 6 in., and shall be marked with gage marks 2 in. apart and placed in the jaws of the testing machine with a maximum distance between jaws of 4 in. The specimen shall be stretched at the rate of 20 in. per minute (jaw speed) until it breaks. The test specimen shall break between the gage marks. The tensile strength shall be calculated upon the area of the original specimen.

Set Test Procedure

30. The set test shall be made on a second test specimen having a length of not less than 6 in. and marked with gage marks 2 in. apart. The specimen shall be placed in the jaws of the testing machine with a maximum distance between jaws of 4 in. and shall be stretched at the rate of 20 in. per minute (jaw speed) until the gage marks are 6 in. apart. The test specimen shall then be released within 5 seconds and the distance between gage marks shall be determined 1 minute after the beginning of release. The set is the difference between this length and the original 2-in. gage length.

Elongation at Rupture Test Procedure

31. The percentage of elongation at rupture shall be determined after the set test and on the same specimen. The specimen shall be placed in the jaws of the testing machine with a maximum distance between jaws of 4 in. and stretched at the rate of 20 in. per minute (jaw speed) until the specimen breaks. The test specimen shall break between the gage marks.

The elongation at rupture shall be taken as the distance between gage marks at rupture less 2 in. (the original gage length of the set test specimen). The percentage of elongation at rupture is the elongation in inches divided by the original gage length (2 in.) and multiplied by 100 to express as a percentage.

AGING TESTS

Aging Test Conditions

32. (*a*) For the aging tests, nine test specimens sampled in accordance with Section 24 taken from the same length of insulation

shall be used; three for the determination of unaged properties, three for the oxygen bomb test and three for the Geer oven test.

(*b*) In the case of wire and cable smaller than No. 6 A.w.g. with an insulation thickness less than $\frac{3}{32}$ in., the insulation shall be heated in the oxygen bomb and in the Geer oven without removing the conductor.

(*c*) In the case of wire and cable of No. 6 A.w.g. and larger or with an insulation thickness greater than $\frac{3}{32}$ in., samples approximately square in section shall be cut from the insulation with a cross-section not greater than 0.025 sq. in.

(*d*) Die-cut samples shall be buffed before being subjected to the accelerated aging test wherever the thickness of the sample is $\frac{3}{32}$ in. or greater after buffing.

(*e*) The test specimens shall have no protective covering and shall be suspended vertically in such a manner that they will not come in contact with each other or with the sides of the bomb or oven.

(*f*) Physical tests on both aged and unaged specimens shall be made at the same time. The aged specimens shall have a rest period of not less than 16 hr. nor more than 48 hr. between the completion of the aging and the determination of the physical properties.

Oxygen Bomb Test

33. The test specimens shall be heated in an atmosphere of oxygen at a pressure of 300 lb. per sq. in. at a temperature of from 157 to 159° F. for a period of 96 hours. The weight of the rubber in the bomb shall not be over 2 g. per cu. in. of bomb space. The bomb pressure shall be reduced at a uniform rate, requiring at least two minutes, when specimens are removed. The bomb temperature shall be recorded automatically on a chart.

Geer Oven Test

34. The test specimens shall be heated at a temperature of from 157 to 159° F. for a period of 96 hours in an oven having a free circulation of fresh air. The oven temperature shall be recorded automatically on a chart.

Retest

35. (*a*) *Tensile Strength, Set, Elongation Tests.*—When tested in accordance with Sections 29, 30 and 31, if a specimen fails to conform to any one of the requirements for tensile strength, set, or elongation at rupture specified in Section 16, two additional specimens shall be taken from the same sample and the average of the results shall determine whether the material conforms to the requirements.

(*b*) *Aging Tests.*—Should the first set of specimens selected under Section 32 (*a*) fail to meet the specifications, two other sets of specimens shall be tested and if either of these sets fails, the coils, reels or lengths will be rejected.

Rejection

36. When ten or more samples are selected in any inspection lot, all coils, reels or lengths shall be rejected if more than 10 per cent of the samples fail. If 10 per cent or less fail, each coil, reel or length may be tested and shall be accepted or rejected upon the results of such individual tests. Where the number of samples selected in any inspection lot is less than ten, all coils, reels or lengths shall be rejected if more than 20 per cent of the samples fail. If 20 per cent or less fail, each coil, reel or length may be tested and shall be accepted or rejected upon the result of such individual tests.

THICKNESS

Apparatus

37. The thickness measurements may be made with any type of micrometer reading to 0.001 in., suitable for measurements of this character.

Number of Measurements

38. Where the lot of wire to be inspected consists of two coils or reels or less, at least one determination of the thickness shall be made on each coil or reel. Where the lot consists of more than two coils or reels and less than 20 coils or reels, at least one determination of the thickness shall be made on each of two coils or reels taken at random. If the lot consists of 20 or more coils or reels, not less than 10 per cent of the coils or reels shall be selected at random and at least one determination of the thickness made on each coil or reel so selected.

Procedure

39. The average thickness of the insulation shall be taken as one-half the difference between the mean of the maximum and minimum diameters measured at any one point and the average diameter of the conductor measured at the same point. The minimum thickness shall be taken as the difference between a measurement made over the conductor plus the thinnest wall and the diameter of the conductor. (The first measurement is made by "slicing off" the heavier side of the insulation.)

In the case of multiple-conductor cable, the measurements shall be made on the individual wires before being cabled.

Rejection

40. If the thickness of the insulation of any coil or reel is found to be less than the specified value, that coil or reel shall be rejected and a thickness measurement on each of the remaining coils or reels shall be made.

ELECTRICAL TESTS

Place of Testing

41. Electrical tests of wire and cable shall be made at the place of manufacture.

TABLE VII.—TEMPERATURE COEFFICIENTS.

Temperature		Temperature Coefficient	Temperature		Temperature Coefficient
Deg. Fahrenheit	Deg. Centigrade		Deg. Fahrenheit	Deg. Centigrade	
46	7.8	0.69	61	16.1	1.03
47	8.3	0.71	62	16.7	1.05
48	8.9	0.73	63	17.2	1.08
49	9.4	0.75	64	17.8	1.11
50	10.0	0.77	65	18.3	1.14
51	10.6	0.79	66	18.9	1.17
52	11.1	0.81	67	19.4	1.20
53	11.7	0.83	68	20.0	1.23
54	12.2	0.85	69	20.6	1.26
55	12.8	0.88	70	21.1	1.30
56	13.3	0.90	71	21.7	1.33
57	13.9	0.92	72	22.2	1.37
58	14.4	0.94	73	22.8	1.40
59	15.0	0.97	74	23.3	1.44
60	15.6	1.00	75	23.9	1.48

High Voltage Test

42. The high voltage test shall be made with alternating potential from a transformer and generator of ample capacity and in no case less than 5 kva. The frequency of the test voltage shall be not greater than 100 cycles and shall have a wave shape approximating as closely as possible a sine curve.

Rate of Application

43. The initially-applied voltage shall be not greater than the rated voltage and the rate of increase shall be approximately uniform and not over 100 per cent in 10 seconds nor less than 100 per cent in 60 seconds.

Immersion in Water

44. (*a*) The outer surface of the insulation of complete insulated wires and cables shall be grounded while being electrically tested.

If the insulation is not provided with a conducting covering, and if the covering is not liable to injury by water, the ground shall be obtained by immersing the insulated wire or cable in water for at least 12 hours and testing at the end of that period while immersed. If the outer covering is susceptible to injury by immersion, the insulated conductor shall be tested before the application of such covering.

(*b*) In the case of multiple-conductor cables, without waterproof overall jacket of insulation, no immersion test shall be made on finished cables, but only on the individual conductors before assembling.

Application of Voltage

45. (*a*) *Single-Conductor Cables.*—Single-conductor cables shall be tested between conductor and sheath or water in which they are immersed.

(*b*) *Multiple-Conductor Cables.*—If a multiple-conductor cable is rated at the same operating voltage between conductor and sheath or water as between conductors, each conductor shall be tested against the other conductors in the cable and against the sheath or water, at the test voltage prescribed for that rated voltage. If a cable is rated at a voltage between conductors and ground different from that between conductors, the test between conductors shall be based upon the rated voltage between conductors and the test between each conductor and sheath or water, shall be based on the rated voltage between conductors and sheath or water.

The several tests may be made by any arrangement of testing transformers suitable for the prescribed tests, such as one or more transformers supplied from a single-phase source or three transtormers connected in star and supplied from a three-phase source.

Insulation Resistance

46. (*a*) The insulation resistance shall be measured after the high-voltage test has been made and while the wire or cable is still immersed in water. The measurement shall be made after one-minute electrification with a continuous e.m.f. of from 100 to 500 volts, the conductor being maintained negative to the water. The temperature of the water shall be within the limits given in Table VII.

Temperature Coefficient

(*b*) If the temperature at which the insulation resistance was measured differs from 60° F. (15.5° C.), the resistance shall be reduced to that at 60° F. (15.5° C.) by multiplying the measured value by the coefficient in Table VII corresponding to the temperature at which the measurement was made.

(*C*) CABLE TAPE

Material

47. The tape shall be made from cotton cloth having a weight of not less than 1 lb. per 4 yd. with a width of 36 in. and not less than 56 by 60 picks per inch, and shall be frictioned on both sides and thoroughly filled with a rubber compound.

Application

48. The tape shall be applied helically and may be applied before vulcanization. The maximum width and minimum overlap shall conform to the values in Table VIII.

TABLE VIII.—WIDTH AND OVERLAP OF RUBBER-FILLED CABLE TAPE.

DIAMETER OVER INSULATION, IN.	MAXIMUM WIDTH OF TAPE, IN.	MINIMUM OVERLAP, IN.
2.00	5	$\frac{1}{2}$
1.75	$4\frac{1}{2}$	$\frac{1}{2}$
1.50	4	$\frac{1}{2}$
1.25	$3\frac{1}{2}$	$\frac{1}{2}$
1.15	$3\frac{1}{4}$	$\frac{1}{2}$
1.00	3	$\frac{1}{2}$
0.88	$2\frac{3}{4}$	$\frac{3}{8}$
0.75	$2\frac{3}{8}$	$\frac{3}{8}$
0.62	2	$\frac{3}{8}$
0.50	$1\frac{3}{4}$	$\frac{3}{8}$
0.38	$1\frac{1}{2}$	$\frac{1}{4}$
0.31	$1\frac{1}{4}$	$\frac{1}{4}$
0.25	1	$\frac{1}{4}$
0.19	$\frac{7}{8}$	$\frac{1}{8}$
0.16	$\frac{3}{4}$	$\frac{1}{8}$

For intermediate diameters the requirements shall be those of the next smaller size.

Intermediate Diameters

49. For intermediate diameters the requirements shall be those of the next smaller diameter indicated in Table VIII.

Number of Tests

50. Samples shall be taken at the option of the purchaser.

(*D*) COTTON BRAID

Braids

51. (*a*) Two types of cotton braid are covered in these specifications, namely, standard braid and heavy braid, as follows:

Standard Braid is designed for indoor service and installation in conduits.

Heavy Braid is designed for outdoor and rough service.

(*b*) Unless otherwise specified, standard braid shall be supplied under these specifications.

Material

52. Cotton braid shall be closely woven from cotton thread having not less than two plies.

Construction

53. (*a*) The braid shall be so constructed that the tangent of the angle between the cotton thread and the side of the wire shall be not less than that specified in Table IX.

TABLE IX.—TANGENT OF ANGLE OF BRAID.

DIAMETER UNDER BRAID, IN.	VALUE OF TANGENT	CORRESPONDING BRAID ANGLE, DEG.
0 to 1.00	0.700	35
1.001 to 1.500	0.839	40
1.501 and over	1.000	45

(*b*) The thickness of standard braid shall be not less than that specified in Table X and that of heavy braid not less than that specified in Table XI.

TABLE X.—MINIMUM THICKNESS OF STANDARD BRAID.

DIAMETER UNDER BRAID, IN.	MINIMUM THICKNESS OF BRAID, IN.	CORRESPONDING MINIMUM SIZE AND PLY OF COTTON YARN
0 to 0.200	0.0163	30/2
0.201 to 0.350	0.0175	26/2
0.351 to 0.800	0.0200	20/2
0.801 to 1.500	0.0258	12/2
1.501 to 3.000	0.0316	8/2

TABLE XI.—MINIMUM THICKNESS OF HEAVY BRAID.

DIAMETER UNDER BRAID, IN.	MINIMUM THICKNESS OF BRAID, IN.	CORRESPONDING MINIMUM SIZE AND PLY OF COTTON YARN
0 to 0.200	0.020	20/2
0.201 to 0.300	0.0223	16/2
0.301 to 0.600	0.0258	12/2
0.601 to 1.000	0.0316	8/2
1.001 to 1.500	0.037	6/2
1.501 to 2.000	0.0446	4/2
2.001 to 3.000	0.0556	4/3

(*c*) The number of carriers and the number of ends per carrier used in applying the braid shall be optional providing all other limitations of Sections 52 and 53 are met. However, the picks per inch shall be not less than the value as calculated by the following formula:

$$P = \sqrt{\left[\frac{1}{tE + M}\right]^2 - \left[\frac{C}{2\pi\,(D + T)}\right]^2}$$

where P = the picks per inch;

T = the thickness of braid, in inches; $T = 2t$

t = the thickness of one end of cotton, in inches; $t = \dfrac{0.0279\,K}{\sqrt{S}}$

K = cabling factor for plied yarn; values of K are: $\begin{cases} \text{2 ply} = 1.60 \\ \text{3 ply} = 2.00 \\ \text{4 ply} = 2.36 \end{cases}$

S = the cotton ply, size or number;

E = the number of ends per carrier;

C = the number of carriers;

D = the diameter under braid, in inches;

M = the space between each set of carrier threads, in inches;

$$M = X\,(0.011 + 7.0\,t^2E^2)$$

X = the closeness constant { Values of X:

Values of X	DIAMETER UNDER BRAID, IN.
1.1......	0 to 0.500
1.0......	0.501 and over

For convenience in calculating the more usual braid constructions, the formula for picks may be reduced to

$$P = \sqrt{Y - \frac{Z}{(D + T)^2}} \text{ where } Y = \frac{1}{(tE + M)^2} \text{ and } Z = \left(\frac{C}{2\pi}\right)^2$$

Values of Y for some of the most commonly used cottons are:

Size of Yarn	Thickness of Braid, T	Values of Y										
		For Diameters Under 0.500 in.				For Diameters 0.501 in. and Over						
		2 End	3 End	4 End	5 End	2 End	3 End	4 End	5 End	6 End	7 End	8 End
30/2	0.0163................	1081	592	358	233	....	....	....	....	....	....	....
26/2	0.0175................	982	526	312	220	....	....	....	....	....	....	....
24/2	0.0182................	930	492	290	185	....	....	....	....	....	....	....
20/2	0.0200................	807	416	241	151	878	446	259	163	....	....	....
16/2	0.0223................	683	339	193	118	738	365	207	127	....	....	....
14/2	0.0238................	616	302	168	103	664	324	180	111	....	....	....
12/2	0.0258................	538	257	142	85	582	276	152	92	59	40	28
10/2	0.0282................	....	....	....	....	497	231	125	74	48	32	22
8/2	0.0316................	....	....	....	....	407	183	96	56	35	23	16

Values of Z for the standard braiders are:

NUMBER OF CARRIERS	VALUES OF Z
12	3.65
16	6.49
20	10.13
24	14.59
36	32.80
48	58.40

(*d*) For braid over twin wires use 1.64 times the conductor diameter to determine the proper braid.

(*e*) Where two braids are specified, the outer braid shall be determined by the diameter over the inner braid. Where the diameter change-over limit is such that Table X and this section require different sizes of yarn on the inner and outer braids, both braids shall be of the size of yarn as required on the outer braid.

(*f*) Where two braids are applied in one operation, these specifications shall apply to the inner and outer braids except that picks per inch and angle of braid for inner braid shall be governed by the construction of the machine.

(*g*) These specifications do not apply to braids for fixture wire or to fancy or special braids.

(*h*) In Table XII are tabulated the required picks per inch as calculated by the formula in Paragraph (*c*) and the corresponding braid angle for braids applied with the minimum size and ply of cotton, and a definite number of ends per carrier. However, it is not the intent of these specifications to limit the braids to the scope of Table XII since heavier cottons or a variation in ends per carrier are permissible providing all requirements of Sections 52 and 53 are fulfilled.

Measurements

54. The various quantities shall be determined as follows:

Diameter Under Braid, by a suitable micrometer reading.

Number of Carriers and *Ends per Carrier*, by examination of braid.

Picks per Inch, on a 4-in. sample after wiping off outside of braid with chloroform.

Angle of Braid by formula: Tangent of Angle $= \dfrac{2\pi P\ (D + T)}{C}$

Thickness of Braid (2 × diameter of single end of cotton), by measuring 25 per cent of the total number of threads with a paper micrometer having a foot 0.4 in. in diameter under a pressure of 50 g. The sample of braid on which the average diameter is determined shall be prepared by immersing a 2-in. length of sample in chloroform in a suitable container for 5 minutes, decanting and repeating for 1 minute, and removing and drying it thoroughly by pressing it between cheese cloth.

TABLE XII.—BRAID.

Diameter Under Braid, *D*, in.	Size and Ply of Cotton Yarn, Minimum	No. of Ends	Thickness of Braid, Minimum, in.	Diameter, Mean Avg. (*D*+*T*), in.	12-Carrier Braiders		16-Carrier Braiders		20-Carrier Braiders		24-Carrier Braiders		36-Carrier Braiders		48-Carrier Braiders	
					Picks per inch	Braid Angle, deg.	Picks per inch	Braid Angle, deg.	Picks per inch	Braid Angle, deg.	Picks per inch	Braid Angle, deg.	Picks per inch	Braid Angle, deg.	Picks per inch	Braid Angle, deg.
STANDARD BRAID																
0.090	30/2	2	0.0163	0.106	27.7	57.0	22.6	43.0	....	....	....	....	....	....	....	....
0.091 to 0.110	30/2	2	0.0163	0.116	28.6	60.0	24.7	48.0	....	....	....	....	....	....	....	....
0.111 to 0.125	30/2	2	0.0163	0.134	29.8	65.0	27.0	55.0	23.0	44.0	....	....	....	....	....	....
0.126 to 0.150	30/2	2	0.0163	0.154	30.6	68.0	28.6	60.0	25.8	51.0	....	....	....	....	....	....
0.151 to 0.175	30/2	2	0.0163	0.179	31.2	71.0	29.8	64.0	27.8	58.0	....	....	....	....	....	....
0.176 to 0.200	30/2	2	0.0163	0.204	31.6	73.0	30.6	68.0	29.1	62.0	....	....	....	....	....	....
0.201 to 0.225	26/2	2	0.0175	0.231	30.2	74.3	29.3	69.4	28.1	63.9	26.6	58.1	....	....	....	....
0.226 to 0.250	26/2	2	0.0175	0.256	30.4	76.2	29.7	71.5	28.8	66.7	27.6	61.6	....	....	....	....
0.251 to 0.300	26/2	2	0.0175	0.293	30.4	78.0	30.2	74.0	29.5	70.0	28.6	65.0	....	....	....	....
0.301 to 0.350	26/2	2	0.0175	0.343	....	....	....	....	30.0	73.0	29.4	69.0	....	....	....	....
0.351 to 0.400	20/2	3	0.020	0.396	....	....	....	....	18.8	66.0	18.0	62.0	....	....	....	....
0.401 to 0.450	20/2	3	0.020	0.445	....	....	....	....	19.1	70.0	18.5	65.0	....	....	....	....
0.451 to 0.500	20/2	3	0.020	0.495	....	....	....	....	19.4	72.0	18.9	68.0	....	....	....	....
0.501 to 0.600	20/2	3	0.020	0.570	....	....	....	....	20.4	75.0	20.1	72.0	....	....	....	....
0.601 to 0.800	20/2	3	0.020	0.720	....	....	....	....	20.6	78.0	20.5	76.0	....	....	....	....
0.801 to 1.000	12/2	4	0.0258	0.925	....	....	....	....	11.8	73.7	11.6	70.3	10.7	59.8	9.2	48.0
1.001 to 1.200	12/2	4	0.0258	1.125	....	....	....	....	12.0	76.8	11.9	74.0	11.2	65.7	10.3	56.6
1.201 to 1.500	12/2	4	0.0258	1.376	....	....	....	....	....	....	12.0	77.0	11.6	70.2	11.0	63.2
1.501 to 2.000	8/2	5	0.0316	1.782	....	....	....	....	....	....	6.2	73.3	6.8	64.6	6.1	55.0
2.001 to 3 000	8/2	5	0.0316	2.532	....	....	....	....	....	....	7.3	78.2	7.1	72.2	6.9	66.2
HEAVY BRAID																
0.090	20/2	2	0.020	0.110	22.6	52.5	16.5	35.5	....	....	....	....	....	....	....	....
0.091 to 0.110	20/2	2	0.020	0.120	23.6	56.0	18.9	41.7	....	....	....	....	....	....	....	....
0.111 to 0.125	20/2	2	0.020	0.138	24.6	58.3	21.5	49.3	....	....	....	....	....	....	....	....
0.126 to 0.150	20/2	2	0.020	0.158	25.7	64.6	23.3	55.3	20.0	44.8	....	....	....	....	....	....
0.151 to 0.175	20/2	2	0.020	0.183	26.4	67.5	24.8	60.5	22.7	52.5	19.2	42.5	....	....	....	....
0.176 to 0.200	20/2	2	0.020	0.208	26.9	70.4	27.5	65.8	23.7	57.0	21.6	49.5	....	....	....	....
0.201 to 0.225	16/2	2	0.0223	0.235	....	....	23.8	56.5	22.4	58.8	20.4	51.5	....	....	....	....
0.226 to 0.250	16/2	2	0.0223	0.260	....	....	25.8	77.8	23.0	62.0	21.6	55.6	....	....	....	....
0.251 to 0.300	16/2	3	0.0223	0.297	....	....	16.3	62.3	15.0	54.5	13.2	49.5	....	....	....	....
0.301 to 0.350	12/2	3	0.0258	0.351	....	....	....	....	13.2	55.4	11.8	47.3	....	....	....	....
0.351 to 0.400	12/2	3	0.0258	0.401	....	....	....	....	13.9	60.1	12.9	53.5	....	....	....	....
0.401 to 0.450	12/2	3	0.0258	0.451	....	....	....	....	14.4	63.9	13.6	58.1	....	....	....	....
0.451 to 0.500	12/2	3	0.0258	0.501	....	....	....	....	14.7	66.6	14.1	62.0	....	....	....	....
0.501 to 0.600	12/2	3	0.0258	0.576	....	....	....	....	....	....	15.2	66.4	13.3	55.7	....	....
0.601 to 0.800	8/2	3	0.0316	0.732	....	....	....	....	....	....	12.5	67.3	11.1	57.2	....	....
0.801 to 1.000	8/2	3	0.0316	0.932	....	....	....	....	....	....	12.9	72.3	12.0	65.0	10.8	53.0
1.001 to 1.200	6/2	2	0.037	1.137	....	....	....	....	....	....	....	....	17.0	74.9	16.4	67.7
1.201 to 1.500	6/2	2	0.037	1.387	....	....	....	....	....	....	....	....	17.2	77.7	16.8	71.8
1.501 to 2.000	4/2	3	0.0446	1.795	....	....	....	....	....	....	....	....	8.6	71.3	8.1	62.3
2.001 to 3.000	4/3	3	0.0556	2.556	....	....	....	....	....	....	....	....	6.6	72.8	6.3	64.5

Number of Tests

55. Samples shall be taken at the option of the purchaser.

(*E*) FINISH

Finish

56. The braid shall be completely saturated with a weather-resisting compound and finished with a black moisture-resistant compound, thoroughly slicked down.

Saturating and Finishing Compounds

57. The saturating and finishing compounds shall have no injurious effect upon the rubber insulation or the coverings during application and shall meet the following tests:

(*a*) *Moisture Absorption Test.*—A 6-in. sample of wire with carefully paraffined ends shall be weighed and submerged in fresh water of a temperature of 20° C. (68° F.) for a period of 24 hr. The increase in weight after submersion and removal of surface water shall be not more than 9 per cent of the weight exclusive of copper and insulation before submersion.

(*b*) *Melt Test.*—A 6-in. sample of wire with the insulation removed for ½ in. at each end shall be placed on clean, white glazed paper and maintained at 52° C. (125° F.) for 30 minutes. The compound shall not migrate sufficiently to be transferred to the paper or form a ridge perceptible to the finger upon it.

(*F*) LEAD SHEATHS

Composition

58. Lead sheaths shall consist of commercially pure lead (approximately 99.85 per cent) without flaws and tightly formed about the taped core of the cable.

TABLE XIII.—THICKNESS OF LEAD SHEATHS.

DIAMETER OF CORE, IN.[a]	THICKNESS OF SHEATH IN $\frac{1}{64}$ IN.
Over 3.000	9
2.001 to 3.000	8
1.501 to 2.000	7
1.051 to 1.500	6
0.701 to 1.050	5
0.426 to 0.700	4
0.000 to 0.425	3

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[a] For twin cables, use the major axis.

Thickness

59. Lead sheaths shall have an average thickness not less than that indicated in Table XIII and the minimum thickness shall in no place be less than 90 per cent of the required average thickness.

Measurement

60. A short section of the lead sheath shall be removed from the wire or cable and the thickness measured with a suitable micrometer caliper at not less than ten points, approximately equally spaced, care being taken to include the thinnest and the thickest parts.

(*G*) INSPECTION AND REJECTION

Inspection and Test

61. (*a*) Inspection shall be made prior to shipment and at the place of manufacture.

(*b*) The manufacturer shall notify the purchaser sufficiently in advance of the completion of the wire or cable to permit of arrangement of inspection.

(*c*) The inspector representing the purchaser shall have free entry at all times, while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the wire ordered, except compounding room. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the wire is being furnished in accordance with these specifications.

(*d*) The purchaser at his option may make the various tests on samples in his own laboratory or elsewhere, but such tests shall be made at the expense of the purchaser.

Rejection

62. Each coil, reel or length which fails to comply with the physical and electrical requirements of these specifications shall be rejected.

Rehearing

63. Samples of rejected material shall be preserved for two weeks from date of test report. In case of dissatisfaction with the results of test, the manufacturer may make claim for a rehearing within that time. Sealed duplicate samples may be retained by the manufacturer at his option.

APPENDIX

ANNEALED COPPER STANDARD[1]

The following shall be taken as normal values for standard annealed copper:

(*a*) *Resistance.*—At a temperature of 20° C. the resistance of a wire of standard annealed copper 1 m. in length and of a uniform section of 1 sq. mm. is $\frac{1}{58}$ ohm = 0.017241 ohm.

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[1] Extracts from American Institute of Electrical Engineers' Standard No. 30.

(*b*) *Density.*—At a temperature of 20° C. the density of standard annealed copper is 8.89 g. per cu. cm.

(*c*) *Temperature Coefficient of Resistance.*—At a temperature of 20° C. the "constant mass" temperature coefficient of resistance of standard annealed copper, measured between two potential points rigidly fixed to the wire, is 0.00393 = 1/254.45 per degree Centigrade.

(*d*) *Resistance of Standard Annealed Copper at 20° C.*—As a consequence, it follows from (*a*) and (*b*) that at a temperature of 20° C. the resistance of a wire of standard annealed copper of uniform section, 1 meter in length and weighing 1 g. is: $\frac{1}{58} \times 8.89 = 0.15328$ ohm.

TENTATIVE SPECIFICATIONS
FOR
INSULATED WIRE AND CABLE: PERFORMANCE RUBBER COMPOUND[1]

A.S.T.M. Designation: D 353 - 33 T

This is a Tentative Standard, published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932; REVISED, 1933.[2]

Scope. 1. (*a*) These specifications cover wire and cable insulated with a vulcanized rubber compound. The suitability of the compound as insulation shall be determined solely by physical and electrical tests. The compound shall be called performance rubber compound.

(*b*) Except for the rubber insulation and methods of testing, wire and cable supplied under these specifications shall conform to the Tentative Specifications for Insulated Wire and Cable: 30 per cent Hevea Rubber (A.S.T.M. Designation: D 27 - 33 T) of the American Society for Testing Materials.[3]

INSULATION

Workmanship. 2. (*a*) The insulation shall be homogeneous in character, tough, elastic and applied concentrically about the conductor and shall fit tightly thereto. Where the insulation is applied in more than one layer adjacent layers shall be vulcanized into a homogeneous mass.

(*b*) The insulation of wires up to No. 7 A. w. g., inclusive, shall be covered with a single cotton braid. On larger sizes the fibrous covering shall consist of a cable tape and cotton braid or two cotton braids. The cable tape may be applied before vulcanization. In multiple conductor cables the individual conductors shall not be braid-covered unless specified.

(*c*) Where repairs or joints are made in the insulation, the work shall be done in such manner that the repaired part of the joint, and all parts affected in the process, shall be as strong and durable electrically and mechanically as the remainder of the insulation and shall not exceed the limitations on the thickness specified in Section 5.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Arthur W. Carpenter, Secretary of Committee D-11 on Rubber Products, The B. F. Goodrich Co., Akron, Ohio.

[2] Revision accepted by Committee E-10 on Standards, August 16, 1933.

[3] See p. 871.

MANUFACTURE

Composition.

3. The insulation shall consist of a properly vulcanized rubber compound that will meet the tests hereinafter specified.

PHYSICAL PROPERTIES

Physical Properties.

4. The insulation shall conform to the following requirements as to physical properties:

	MAXIMUM	MINIMUM
Ultimate tensile strength, lb. per sq. in.	..	1200
Tensile stress at 200 per cent elongation, lb. per sq. in.	..	300
Elongation at rupture, per cent	..	400
Set in 2-in. gage length, in.	$\frac{3}{8}$	....
Depreciation in tensile strength and elongation after oxygen bomb test, per cent	25	....
Depreciation in tensile strength and elongation after Geer oven test, per cent	15	....

THICKNESS

Thickness.

5. The average thickness of the insulation shall be not less than that given in Table I. The thickness of the insulation at the thinnest part shall be not more than 10 per cent less than the specified thickness, but in no case shall such 10 per cent allowance exceed 0.031 in.

TABLE I.—THICKNESS OF INSULATION.

Thickness in sixty-fourths of an inch

Size of Conductor		Working Pressure, Volts, Direct or Alternating Commercial Power Frequencies											
A. w. g. Numbers or Circular Mils	sq. mm.	600 or less	750	1500	2500	3500	5000	6000	7000	8000	9000	10 000	11 000
No. 14 to No. 9	2.08 to 6.63	3	4	6	8	10	12	..	..	..	..	..	..
No. 8 to No. 2	8.37 to 33.6	4	5	7	9	10	12	14	16	18	20	22	24
No. 1 to No. 0000	42.4 to 107	5	6	8	10	10	12	14	16	18	20	22	24
250 000 to 500 000 cir. mils	127 to 253	6	8	9	10	11	12	14	16	18	20	22	24
550 000 to 1 000 000 cir. mils	279 to 507	7	9	10	10	12	12	14	16	18	20	22	24
1 250 000 to 2 000 000 cir. mils	633 to 1013	8	10	10	10	12	14	16	18	18	20	22	24

NOTE.—The thickness of insulation (on each conductor in the case of multiple conductor cables) shall be based on the highest r. m. s. voltage between the conductor and the outside of its insulation.

For an intermediate size or an intermediate working voltage the thickness shall be that for the next larger size or higher working voltage.

ELECTRICAL PROPERTIES

High Voltage Test.

6. Each coil, reel, or length of wire or cable after vulcanization and before the application of any covering other than tape used in vulcanization shall successfully withstand the application of an alternating voltage of not less than that given in Table II for a period of 5 minutes.

Insulation Resistance. 7. Each coil, reel, or length of wire or cable after being subjected to the high voltage test specified in Section 6 shall have an insulation resistance not less than that given in Table III.

Moisture Absorption. 8. (*a*) The increase in the specific inductive capacity of the insulation shall be used as an indication of the amount of moisture absorbed.

(*b*) The specific inductive capacity after 24-hr. immersion in water shall not exceed six. The increase between the ends of the first and the fourteenth days shall not exceed 20 per cent and that between the ends of the seventh and fourteenth days, 5 per cent.

(*c*) The specific inductive capacity shall be determined at either 1000 or 60 cycles. Where measured at 1000 cycles, the voltage impressed upon the conductor shall not exceed 10 volts. Where measured at 60 cycles, the voltage impressed upon the conductor shall be equivalent to a stress of between 30 to 40 volts per mil of insulation.

(*d*) The measurements shall be made as described in Section 32.

TABLE II.—ALTERNATING TEST VOLTAGE IN KILOVOLTS.

Size of Conductor		Working Pressure, Volts, Direct or Alternating Commercial Power Frequencies											
A. w. g. Numbers or Circular Mils	sq. mm.	600 or less	750	1500	2500	3500	5000	6000	7000	8000	9000	10 000	11 000
No. 14 to No. 9	2.08 to 6.63	3	4	6	8	10	13	..	..	..	..	..	..
No. 8 to No. 6	8.37 to 13.3	3.5	5	7	9	10	13	16	17	18	20	22	24
No. 5 to No. 2	16.8 to 33.6	3.5	5	7	9	10	13	16	19	22	25	28	31
No. 1 to No. 0000	42.4 to 107	3.5	6	8	10	10	13	16	19	22	25	28	31
250 000 to 500 000 cir. mils	127 to 253	4	8	9	10	11.5	13	16	19	22	25	28	31
550 000 to 1 000 000 cir. mils	279 to 507	4	9	10	10	13	13	16	19	22	25	28	31
1 250 000 to 2 000 000 cir. mils	633 to 1013	4	10	10	10	13	16	19	22	22	25	28	31

NOTE.—For an intermediate size or an intermediate working voltage, the test voltage shall be that of the next larger size, or higher working voltage.

METHODS OF TESTING

TENSILE STRENGTH, SET, AND ELONGATION AT RUPTURE

Sampling. 9. (*a*) Wire up to and including 250,000 cir. mils in size shall be sampled in accordance with the following requirements:

	NUMBER OF SAMPLES
2000 ft. and under	none
2001 to 10,000 ft	1 for each 2000 ft. or fraction thereof
10,001 to 100,000 ft	5 plus 1 for each 10,000 ft. additional over 10,000 ft.
100,001 to 500,000 ft	14 plus 1 for each 25,000 ft. over 100,000 ft.

(*b*) For wire larger than 250,000 cir. mils, one sample shall be selected from quantities between 1000 and 2000 ft. and for larger quantities double those specified in Paragraph (*a*).

Test Specimen. 10. (*a*) *Size.*—For the physical tests, the test specimen may be the entire cross-section of the insulation in the case of small wires, or, in the case of a large wire or cable, either a segment or sector cut with a sharp knife held tangentially to the conductor or a shaped specimen cut out with a standard die. The test specimen shall be as free as possible from surface incisions and imperfections. There shall be no limit to the cross-section of the test specimen, except as restricted by the capacity of the testing machine.

TABLE III.—INSULATION RESISTANCE, MEGOHMS-1000 FT. AT 60° F. (15.5° C.).[a]

Size of Conductor, A. w. g. Numbers or Circular Mils	Thickness of Insulation in Sixty-fourths of an Inch							
	2	3	4	5	6	7	8	10
No. 18	8400	10 800	....	....	....	....	....	....
No. 16	7400	9 500	....	....	....	....	....	....
No. 14	....	8 100	9 800	11 400	12 400	13 500	14 000	16 100
No. 12	....	7 100	8 400	9 800	10 800	11 900	12 700	14 500
No. 10	....	6 050	7 150	8 400	9 500	10 600	11 400	12 700
No. 8	....	4 500	5 550	5 600	7 650	8 700	9 200	10 800
No. 6	....	....	4 500	5 550	6 350	7 150	7 650	9 200
No. 4	....	....	3 950	4 500	5 300	6 050	6 600	7 650
No. 2	....	....	3 450	3 950	4 500	5 000	5 550	6 600
No. 1	....	....	3 150	3 450	3 950	4 500	5 300	6 050
No. 0	....	....	....	3 150	3 700	4 200	5 000	5 550
No. 00	....	....	....	2 900	3 450	3 950	4 500	5 000
No. 000	....	....	....	2 650	3 150	3 450	3 950	4 500
No. 0000	....	....	....	2 400	2 900	3 150	3 450	4 200
250 000 cir. mils	....	....	....	2 100	2 500	3 050	3 300	3 850
350 000 cir. mils	....	....	....	1 850	2 250	2 500	2 750	3 550
500 000 cir. mils	....	....	....	1 600	2 000	2 100	2 500	3 050
750 000 cir. mils	....	....	....	....	....	1 700	2 100	2 500
1 000 000 cir. mils	....	....	....	....	....	1 600	1 700	2 100
1 250 000 cir. mils	....	....	....	....	....	....	1 700	2 000
1 500 000 cir. mils	....	....	....	....	....	....	1 600	1 700
1 750 000 cir. mils	....	....	....	....	....	....	1 450	1 600
2 000 000 cir. mils	....	....	....	....	....	....	1 050	1 450

Size of Conductor, A. w. g. Numbers or Circular Mils	Thickness of Insulation in Sixty-fourths of an Inch						
	12	14	16	18	20	22	24
No. 14	17 700	....	....	....	....	....	....
No. 12	15 800	....	....	....	....	....	....
No. 10	14 000	....	....	....	....	....	....
No. 8	11 600	12 700	13 700	14 500	15 300	16 100	16 600
No. 6	10 300	11 100	12 100	12 900	13 500	14 300	14 800
No. 4	8 700	9 800	10 600	11 400	11 900	12 700	13 200
No. 2	7 650	8 400	9 000	9 800	10 300	11 100	11 600
No. 1	150	7 650	8 400	9 200	9 800	10 300	10 800
No. 0	6 350	7 150	7 900	8 400	9 000	9 500	10 000
No. 00	5 550	6 600	7 150	7 900	8 400	9 000	9 500
No. 000	5 300	6 050	6 600	7 150	7 650	8 200	....
No. 0000	5 000	5 550	6 050	6 600	7 150	7 650	....
250 000 cir. mils	4 600	5 300	5 800	6 350	6 750	....	....
350 000 cir. mils	4 100	4 500	5 000	5 550	5 950	....	....
500 000 cir. mils	3 550	3 950	4 500	4 750	....	....	....
750 000 cir. mils	2 750	3 300	3 700	4 100	....	....	....
1 000 000 cir. mils	2 500	2 900	3 300	....	....	....	....
1 250 000 cir. mils	2 250	2 650	3 050	....	....	....	....
1 500 000 cir. mils	2 100	2 500	....	....	....	....	....
1 750 000 cir. mils	2 000	2 400	....	....	....	....	....
2 000 000 cir. mils	1 700	2 250	....	....	....	....	....

[a] This table is based on a constant, $K = 21\,120$ in the following formula:

$$R = K \log_{10}\frac{D}{d};$$ where R = resistance in megohms-1000 ft., K = constant,

D = diameter over insulation, on each conductor, and d = diameter over conductor.

NOTE.—For an intermediate size, the insulation resistance shall be that of the next larger size.

NOTE.—The removal of the rubber insulation can be greatly accelerated and in most cases a test specimen which is an entire cross-section can be obtained free from surface incisions and imperfections by means of metallic mercury. The mercury should be introduced at one end of the sample between the insulation and the tinned surface of the conductor, and the sample inclined on a support with the end to which the mercury is applied at the top. The separation of the rubber insulation results from the amalgamation of the tin of the conductor with the mercury. The amalgamation is assisted by first immersing and rubbing the tinning on the exposed end of the conductor in the mercury.

(*b*) *Condition and Age.*—Specimens shall not be heated, immersed in water or subjected to any mechanical or chemical treatment not specifically prescribed in these specifications.

Specimens for accelerated aging tests shall be taken from the completed wire after the application of the specified covering and shall be aged with all such covering removed.

No tests shall be made within 24 hours nor later than 60 days after vulcanization unless agreed to by the manufacturer.

(*c*) *Buffing.*—In the event of any irregularities on the surface of the test specimen, it shall be made smooth and of uniform thickness within 5 per cent of the original thickness by buffing, except when large strands are used, in which case the rubber sample shall be buffed sufficiently to remove all corrugations.

Calculation of Area.

11. Calculation of the area of the test specimens shall be made as follows:

(*a*) Where the total cross-section of the insulation is used, the area shall be taken as the difference between the area of the circle whose diameter is the average outside diameter of the insulation and the area of the conductor. The area of the stranded conductor shall be calculated from its maximum diameter.

(*b*) Where a segment or sector of the insulation has to be taken in the case of a large wire or cable or where the insulation is thin, the area shall be calculated as the thickness times the width. (This applies either to a straight test specimen or one stamped out with a die, and assumes that corrugations have been removed by buffing.)

Temperature at Test.

12. Physical tests shall be made at a room temperature not less than 65° F. (18.3° C.) nor more than 90° F. (32.2° C.) and the test specimen shall have been kept at the room temperature not less than 30 minutes prior to the test.

Tension Testing Machine.

13. The tension testing machine shall be power-driven and preferably of the pendulum type. The machine shall be accurate within 1 per cent of the breaking load. A spring balance type of apparatus may be used if provided with a device which will indicate the actual maximum load at which rupture takes place and if provision is made to prevent recoil of the spring.

Tensile Strength Tests.

14. The tensile strength test shall be made on a specimen which has not been previously stretched. The specimen shall have a length of not less than 6 in., and shall be marked with gage marks 2 in. apart and placed in the jaws of the testing machine with a maximum distance between jaws of 4 in. The specimen shall be stretched at the rate of 20 in. per minute (jaw speed) until it breaks. The test specimen shall break between the gage marks. The tensile strength shall be calculated upon the area of the original specimen.

Tensile Stress Test.

15. The tensile stress test shall be made in conjunction with the tensile strength test by recording the load when the 2-in. gage length marks are 6 in. apart, that is, at 200 per cent elongation. The tensile stress shall be calculated upon the area of the original specimen.

Elongation at Rupture.

16. Elongation at rupture shall be determined in conjunction with the tensile strength test by reading the distance in inches between gage marks at the breaking point. The elongation at rupture shall be taken as the distance between gage marks at rupture less 2 in. (the original gage length). The percentage of elongation at rupture is the elongation in inches divided by the original gage length (2 in.) and multiplied by 100 to express as a percentage.

Set Test.

17. The set test shall be made on a second test specimen having a length of not less than 6 in. and marked with gage marks 2 in. apart. The specimen shall be placed in the jaws of the testing machine with a maximum distance between jaws of 4 in. and shall be stretched at the rate of 20 in. per minute (jaw speed) until the gage marks are 6 in. apart. The test specimen shall then be released within 5 seconds and the distance between gage marks shall be determined 1 minute after the beginning of release. The set is the difference between this length and the original 2-in. gage length.

AGING TESTS

Aging Test Conditions.

18. (*a*) For the aging tests, nine test specimens sampled in accordance with Section 9 taken from the same length of insulation shall be used; three for the determination of unaged properties, three for the oxygen bomb test and three for the Geer oven test.

(*b*) In the case of wire and cable smaller than No. 6 A.w.g. with an insulation thickness less than $\frac{3}{32}$ in., the insulation shall be heated in the oxygen bomb and in the Geer oven without removing the conductor.

(*c*) In the case of wire and cable of No. 6 A.w.g. and larger or with an insulation thickness greater than $\frac{3}{32}$ in., samples approximately square in section shall be cut from the insulation with a cross-section not greater than 0.025 sq. in.

(*d*) Die-cut samples shall be buffed before being subjected to the accelerated aging test wherever the thickness of the sample is $\frac{3}{32}$ in. or greater after buffing.

(*e*) The test specimens shall have no protective covering and shall be suspended vertically in such a manner that they will not come in contact with each other or with the sides of the bomb or oven.

(*f*) Physical tests on both the aged and unaged specimens shall be made at the same time. The aged specimens shall have a rest period of not less than 16 hours nor more than 48 hours between the completion of the aging test and determination of physical properties.

(*g*) Should the first set of specimens selected under Paragraph (*a*) fail to meet the specifications, two other sets of specimens shall be tested and if either of these sets fails, the coils, reels or lengths will be rejected.

Oxygen Bomb Test. 19. The test specimens shall be heated in an atmosphere of oxygen at a pressure of 300 lb. per sq. in. at a temperature of from 157 to 159° F. for a period of 96 hours. The weight of the rubber in the bomb shall not be over 2 g. per cu. in. of bomb space. The bomb pressure shall be reduced at a uniform rate, requiring at least two minutes, when specimens are removed. The bomb temperature shall be recorded automatically on a chart.

Geer Oven Test. 20. The test specimens shall be heated at a temperature of from 157 to 159° F. for a period of 96 hours in an oven having a free circulation of fresh air. The oven temperature shall be recorded automatically on a chart.

Rejection. 21. Where ten or more samples are selected in any inspection lot, all coils, reels or lengths shall be rejected if more than 10 per cent of the samples fail. If 10 per cent or less fail, each coil, reel or length may be tested and shall be accepted or rejected upon the results of such individual tests. Where the number of samples selected in any inspection lot is less than ten, all coils, reels or lengths shall be rejected if more than 20 per cent of the samples fail. If 20 per cent or less fail, each coil, reel or length may be tested and shall be accepted or rejected upon the results of such individual tests.

THICKNESS MEASUREMENTS

Apparatus. 22. The thickness measurements may be made with any type of micrometer reading to 0.001 in., suitable for measurements of this character.

Number of Measurements. 23. Where the lot of wire to be inspected consists of two coils or reels or less, at least one determination of the thickness shall be made on each coil or reel. Where the lot consists of more than two coils or reels and less than 20 coils or reels, at least one determination of the thickness shall be made on each of two coils or reels taken at random. If the lot consists of 20 or more coils or reels, not less than

10 per cent of the coils or reels shall be selected at random and at least one determination of the thickness made on each coil or reel so selected.

Procedure. 24. The average thickness of the insulation shall be taken as one-half the difference between the mean of the maximum and minimum diameters measured at any point and the average diameter of the conductor measured at the same point. The minimum thickness shall be as taken the difference between a measurement made over the conductor plus the thinnest wall and the diameter of the conductor. (The first measurement is made by "slicing off" the heavier side of the insulation.)

In the case of multiple-conductor cable, the measurements shall be made on the individual wires before being cabled.

Rejection. 25. If the thickness of the insulation of any coil or reel is found to be less than the specified value, that coil or reel shall be rejected and a thickness measurement on each of the remaining coils or reels shall be made.

ELECTRICAL TESTS

Place 26. Electrical tests of wire and cable shall be made at the place of manufacture.

High Voltage Test. 27. The high voltage test shall be made with alternating potential from a transformer and generator of ample capacity and in no case less than 5 kva. The frequency of the test voltage shall be not greater than 100 cycles and shall have a wave shape approximating as closely as possible a sine curve

Rate of Application. 28. The initially applied voltage shall be not greater than the rated voltage and the rate of increase shall be approximately uniform and not over 100 per cent in 10 seconds nor less than 100 per cent in 60 seconds.

Grounding. 29. (*a*) The outer surface of the insulation of complete insulated wires and cables shall be grounded while being electrically tested. If the insulation is not provided with a conducting covering, and if the covering is not liable to injury by water, the ground shall be obtained by immersing the insulated wire or cable in water for at least 12 hours and testing at the end of that period while immersed. If the outer covering is susceptible to injury by immersion, the insulated conductor shall be tested before the application of such covering.

(*b*) In the case of multiple-conductor cables, without waterproof overall jacket of insulation, no immersion test shall be made on finished cables, but only on the individual conductors before assembling.

Application of Voltage.

30. (*a*) *Single-Conductor Cables.*—Single-conductor cables shall be tested between conductor and sheath or water in which they are immersed.

(*b*) *Multiple-Conductor Cables.*—If a multiple-conductor cable is rated at the same operating voltage between conductor and sheath or water as between conductors, each conductor shall be tested against the other conductors in the cable and against the sheath or water, at the test voltage prescribed for that rated voltage. If a cable is rated at a voltage between conductors and ground different from that between conductors, the test between conductors shall be based upon the rated voltage between conductors and the test between each conductor and sheath or water, shall be based on the rated voltage between conductors and sheath or water.

TABLE IV.—TEMPERATURE COEFFICIENTS.

Temperature		Temperature Coefficient	Temperature		Temperature Coefficient
Deg. Fahrenheit	Deg. Centigrade		Deg. Fahrenheit	Deg. Centigrade	
46	7.8	0.69	61	16.1	1.03
47	8.3	0.71	62	16.7	1.05
48	8.9	0.73	63	17.2	1.08
49	9.4	0.75	64	17.8	1.11
50	10.0	0.77	65	18.3	1.14
51	10.6	0.79	66	18.9	1.17
52	11.1	0.81	67	19.4	1.20
53	11.7	0.83	68	20.0	1.23
54	12.2	0.85	69	20.6	1.26
55	12.8	0.88	70	21.1	1.30
56	13.3	0.90	71	21.7	1.33
57	13.9	0.92	72	22.2	1.37
58	14.4	0.94	73	22.8	1.40
59	15.0	0.97	74	23.3	1.44
60	15.6	1.00	75	23.9	1.48

The several tests may be made by any arrangement of testing transformers suitable for the prescribed tests, such as one or more transformers supplied from a single-phase source or three transformers connected in star and supplied from a three-phase source.

Insulation Resistance.

31. (*a*) The insulation resistance shall be measured after the high voltage test has been made and while the wire or cable is still immersed in water. The measurement shall be made after one minute electrification with a continuous e.m.f. of from 100 to 500 volts, the conductor being maintained negative to the water. The temperature of the water shall be within the limits given in Table IV.

Temperature Coefficient.

(*b*) If the temperature at which the insulation resistance was measured differs from 60° F. (15.6° C.), the resistance shall be reduced to that at 60° F. (15.6° C.) by multiplying the measured value by the coefficient in Table IV corresponding to the temperature at which the measurement was made.

Moisture Absorption Test.

32. (*a*) A 15-ft. sample with all the coverings removed shall be selected at random from the wire offered for inspection. The middle 10 ft. of the sample shall be immersed in distilled water for a period of 14 days with the $2\frac{1}{2}$-ft. portion at each end kept above the water as leakage insulation. The three measurements specified in Section 8 shall be taken with the water at the same temperature. The water shall be maintained at room temperature but not less than 70° F. (21° C.).

(*b*) The specific inductive capacity of the insulation shall be determined at commercial frequencies and shall be calculated as follows:

$$\text{Specific inductive capacity} = 13\,600\ C \log_{10} \frac{D}{d}$$

where C = the capacity in micro-farads of 10 ft. of sample;
D = the diameter over insulation; and
d = the diameter over conductor.

The moisture absorption test shall be made only when requested by the purchaser.

Rejection.

33. Each coil, reel or length which fails to comply with the electrical requirements of these specifications shall be rejected.

TENTATIVE METHODS OF TESTING RUBBER BELTING USED FOR POWER TRANSMISSION[1]

A.S.T.M. Designation: D 378 – 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1933.[2]

Scope

1. These methods cover the test procedure recommended for evaluating the physical properties of the flat type of rubber belting for power transmission which contains cotton duck reinforcement and is classified commercially as follows:

(*a*) *Friction Surface Belt.*—Possessing no distinct rubber cover other than that resulting from the rubber frictioning process.

(*b*) *Rubber Covered Belt.*—Possessing a distinct rubber cover extending over the outside and around the edges of the belt.

Sampling

2. Samples selected for purpose of tests shall be of the full width and thickness of the belt. For belts under 8 in. in width the length of the sample shall be not less than 32 in. and for belts 8 in. and over not less than 26 in.

Preliminary Examination

3. A careful surface examination to determine visual manufacturing defects shall be made of the belt sample and its condition noted.

Measurement

4. (*a*) *Width.*—The width shall be determined by laying across the belt a steel rule or tape graduated to sixteenths of an inch. The width shall be recorded in inches and fractions thereof.

(*b*) *Thickness.*—The thickness of the belts and covers shall be determined by means of a micrometer graduated to thousandths of an inch, and having a presser foot 0.25 in. ± 0.01 in. in diameter, exerting a pressure of 9 oz. ± 0.1 oz. on the test specimen. The pressure should be applied by means of a weight.

(*1*) *Cover Thickness $\frac{3}{64}$ in. or over.*—The thickness of the top or bottom cover when $\frac{3}{64}$ in. or over shall be the minimum thickness found on the unbuffed cover.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. Arthur W. Carpenter, Secretary of Committee D-11 on Rubber Products, The B. F. Goodrich Co., Akron, Ohio.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 16, 1933.

(*2*) *Cover Thickness under $\frac{3}{64}$ in.*—The thickness of the top and bottom covers shall be the minimum thickness found on the test specimen prepared for the adhesion test (Section 9) and shall be determined as follows: The over all thickness of the test specimen shall be measured. The rubber covers shall be stripped from the test specimen and the thickness of the carcass measured. The difference between these measurements represents the thickness of the two covers which shall be considered as being uniformly distributed, provided the fabric is thoroughly coated on the outside.

Test Conditions

5. Tests shall be made within a temperature range of 65 to 90 F. The samples shall be kept at a temperature between these limits at least 30 minutes previous to the time of testing. The values obtained in determining the physical properties under these methods will differ depending upon the age of the sample; therefore, the test shall be made within a definite time limit which shall not exceed 60 days from receipt of the material.

TENSION TEST

Tension Test Apparatus

6. (*a*) Specimens shall be tested in a suitable vertical testing machine equipped with wedge-shaped jaws. The base of the jaws shall be at right angles to the longitudinal center of the test specimen when correctly placed in the jaws. The base surfaces of the two edges of each set of jaws shall be in the same horizontal plane and adequate means shall be provided to lock the two halves of the jaws so that they will travel together in parallelism. Means shall be provided to hold the jaws in convenient position to correctly insert the test specimen as well as to loosen them after each test. The heads of the testing machine shall be constructed to provide rigid support for the jaws. The inner surfaces of the wedge-shaped slots shall be machined to within 0.005 in. of a true plane. The included angle of the two sides shall be from 17.5 to 22 deg. and this angle must be identical with that of the jaws.

(*b*) The rate of separation of the jaws shall be from $\frac{3}{4}$ to 2 in. per minute, inclusive.

Tension Test Specimen

7. For belting up to 5 in. in width, inclusive, a longitudinal tension test specimen 20 in. in length and the full width of the belt shall be cut from the test sample. For belting over 5 in. in width, the test specimen shall be 20 in. in length by 5 in. in width and the

edges of the specimen shall be cut parallel to and at least $\frac{1}{2}$ in. from the edges of the belt. The thickness of the test specimen shall not exceed four plies. Excess plies shall be removed by stripping, removing them alternately from each face. When testing rubber covered belts, rubber covers $\frac{1}{16}$ in. and over in thickness shall be stripped from the test specimen.

Tension Test Procedure

8. (*a*) *Tensile Strength.*—The grooves and gripping surfaces of the jaws shall be cleaned and the edge surfaces and backs shall be well lubricated and kept free of any foreign matter. Slippage may be prevented by the use of coarse emery cloth which shall be inserted between the corrugations of the jaws and the test specimen, with the rough side toward the specimen, and this cloth shall be renewed frequently. Great care must be used to prevent the loose particles of grit which fall from the emery cloth from lodging upon any of the pressure surfaces during the test. The test specimen shall be tested in the machine described in Section 6 at the specified rate of speed. If the specimen breaks in the jaws the results shall be discarded and the test shall be repeated. From the breaking strength thus determined, the tensile strength of the belt per inch of width per ply shall be calculated and reported.

(*b*) *Elongation.*—The elongation, when required, shall be taken during the performance of the tensile strength test. For this purpose, parallel reference lines 8 in. apart shall be marked across the middle of the test specimen at right angles to the longitudinal axis and the specimen placed squarely in the jaws of the machine. The elongation shall be determined by means of a steel scale or suitable extensometer. When an extensometer is used, it shall be pinned or held on the specimen with the points on the 8-in. reference lines and the scale set at zero. The load shall then be applied at the specified rate of speed and the elongation at the breaking point shall be noted.

(*c*) *Stress-Strain.*—If the stress-strain characteristics of the belt are desired they may be obtained simultaneously with the tensile strength determination. In this case, elongation readings of the steel scale or extensometer shall be taken at intermediate points. The total load on the belt and the percentage elongation for each increment increase in load per inch per ply shall be reported as well as the total load and percentage elongation at failure.

ADHESION TEST

Adhesion Test Specimen

9. The adhesion test specimens shall be prepared by accurately cutting a strip 1 in. in width longitudinally of the test sample from

belts under 8 in. in width and transversely from belts 8 in. and over in width. The test specimen shall be at least 6 in. in length. The various plies shall be separated at one end of the test specimen a sufficient distance to permit attaching the jaws of the testing clamp.

Adhesion Test

10. (*a*) The adhesion between plies shall be determined by the dead weight method, that is, through the application of a specified load on successive plies of a specimen 1 in. in width in such a manner as to cause separation. Adhesion shall be expressed numerically as the average rate of separation in inches per minute.

(*b*) The test specimen shall be suspended by the separated end, all plies of which except the one under test shall be clamped in the jaws of the testing clamp. A minimum weight sufficient to maintain the test specimen in approximately a vertical position shall be attached to its lower end. The first ply shall have the specified weight attached to the separated end with suitable provision for supporting and releasing it slowly without jerking. A mark shall be placed on the line of separation at the beginning and at the end of the test. After the weight is removed at the end of the test, the distance between the marks shall be measured. The ply shall be tested over a sufficient distance to indicate its adhesion value. The duration of the test shall be timed with a stop watch or watch with a second hand. Under these conditions the rate of separation shall not exceed 1 in. per minute.

(*c*) The test shall be continued on the successive plies by releasing the separated end of each from the stationary clamp and reattaching the specified weight. This procedure shall be followed until two plies only remain within the grip of the stationary clamp. No tests shall be made between the last two plies of the test specimen (Note). When tests are desired on these plies, a second specimen shall be prepared and shall be tested, starting from the opposite side in accordance with the above outlined procedure.

NOTE.—The last two plies are omitted from the test because sufficient rigidity cannot be maintained at the point of separation to obtain the approximate condition of separation in a vertical plane.

BEADING TEST

Beading Test

11. The beading in all friction surface belting 4 in. in width or over shall be tested as follows:

A 4-in. transverse section of belting shall be taken and beginning on the seamless side, the plies shall be removed until three plies only remain intact. A line shall be drawn down the middle of the beading and then on each side of this line, and $\frac{5}{8}$ in. distant from it, two parallel lines shall be scribed. The section shall be inserted in a vise so that the jaws grip the sample coincident with the two outer lines. The vise shall be tightened until the inner surfaces of the doubled samples just touch at the top of the vise, and the sample shall be held in this position for 10 minutes. Under this test the beading shall not crack or loosen in the seam.

INSPECTION AND REJECTION

Inspection

12. (*a*) All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified. The manufacturer shall afford the inspector, without charge, all reasonable facilities to test and inspect the belting.

(*b*) The purchaser may make the tests and inspection to govern the acceptance or rejection of the material in his own laboratory or elsewhere. Such tests and inspection shall be made at the expense of the purchaser, not later than 60 days after receipt of the material.

Retests and Rejection

13. (*a*) Any material which fails in one or more tests may be resampled and retested at the expense of the manufacturer. For this purpose two additional samples shall be selected from the belt for the test which failed to meet the requirements. Failure of either of the retested samples shall be cause for final rejection.

(*b*) Rejected material shall be returned to the manufacturer at his expense.

TENTATIVE METHODS OF TEST[1]

FOR

RUBBER HOSE-BRAIDED CONSTRUCTION[1]

A.S.T.M. Designation: D 379 – 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1933.[2]

Scope

1. These methods shall be employed in the examination and test of rubber hose wherein the reinforcement is fabric braided during the manufacture of the hose.

Sampling

2. A sample of sufficient length for proper performance of the tests specified herein shall be cut from the hose. The pieces of hose from which samples have been cut shall be accepted by the purchaser as full length, provided the hose meets the specified requirements. In general, the amount required and the frequency of sampling for each size and type of braided hose shall be one 24-in. sample from 500 ft. or fraction thereof of hose over $1\frac{1}{4}$ in. in nominal diameter and one 36-in. sample from 500 ft. or fraction thereof of hose $1\frac{1}{4}$ in. or under in nominal diameter.

Measurement of Hose

3. (*a*) *Length.*—The length shall be determined by means of a steel tape or calibrated measuring device and shall not include length of fittings except when specifically so requested and recorded.

(*b*) *Outside Diameter.*—The outside diameter shall be determined by calculation from measurement of the outside circumference. A tape graduated to read the diameter directly may be used.

(*c*) *Inside Diameter.*—The inside diameter shall be measured with a plug gage on hose of 3 in. and under in nominal diameter. On larger hose, a steel scale or caliper may be used.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. Arthur W. Carpenter, Secretary of Committee D-11 on Rubber Products, The B. F. Goodrich Co., Akron, Ohio.

These tentative methods are in effect a revision of and replace the former Standard Specifications for Braided Air Hose for Use with Pneumatic Tools (A.S.T.M. Designation: D 60 - 24), which standard was accordingly discontinued in 1933.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 16, 1933.

Thickness of Tube and Cover

4. (*a*) The minimum thickness of the tube and cover shall be taken as the average between two measurements of thickness, one of which shall be obtained using the unbuffed specimen and the other of which shall be obtained using a specimen which is buffed smooth just sufficiently to remove surface corrugations. Tension test specimens may be used for the measurement of the buffed thickness providing excess thickness has not been removed in the buffing operation.

(*b*) The thickness of the tube and cover shall be determined by means of a micrometer graduated to thousandths of an inch and having a presser foot 0.25 in. ± 0.01 in. in diameter, exerting a total force of 9 oz. ± 0.1 oz. The load shall be applied by means of a weight.

Test Conditions

5. The temperature of the testing room shall be between 65 and 90 F. The samples to be tested shall be kept in this room for at least 30 minutes previous to the time of testing.

TENSILE STRENGTH AND ELONGATION OF RUBBER

Tension Test Apparatus

6. (*a*) *Testing Machine.*—Tensile strength and elongation tests shall be made on apparatus accurate within ±1 per cent and provided with an accurate device for indicating the actual maximum load at rupture. The preferred type of apparatus is a power-driven machine of the inclination-balance or pendulum type, but a spring balance accurately calibrated may be used.

(*b*) *Grips for Testing.*—The grips for holding the test specimen shall be such that they tighten automatically, exerting a uniform pressure, proportional to the applied tension, across the full width of the enlarged end of the test specimen. The moving grip shall move at a constant speed of 20 in. per minute.

Tension Test Specimen

7. (*a*) *Separation of Rubber Parts.*—Sufficient length shall be cut from the hose sample to provide longitudinal tension test specimens from hose 1¼ in. and under in nominal diameter and transverse test specimens on larger sizes. The rubber parts to be tested shall be separated from the balance of the hose without the use of gasoline, if possible. If it is necessary to employ gasoline to effect the separation, it shall be of a grade distilling below 150 C. and which, upon evaporation, does not leave an appreciable amount of oily residue. After use of gasoline, the test specimen shall be allowed to rest at least an hour before testing.

(*b*) *Preparation of Specimen.*—The test specimen shall be stamped out from the separated rubber part with dies conforming to Fig. 1 *A*, *B* or *C*. In no case shall the thickness of the test specimen exceed ⅛ in. Test specimens shall be free from marked irregularities of thickness.

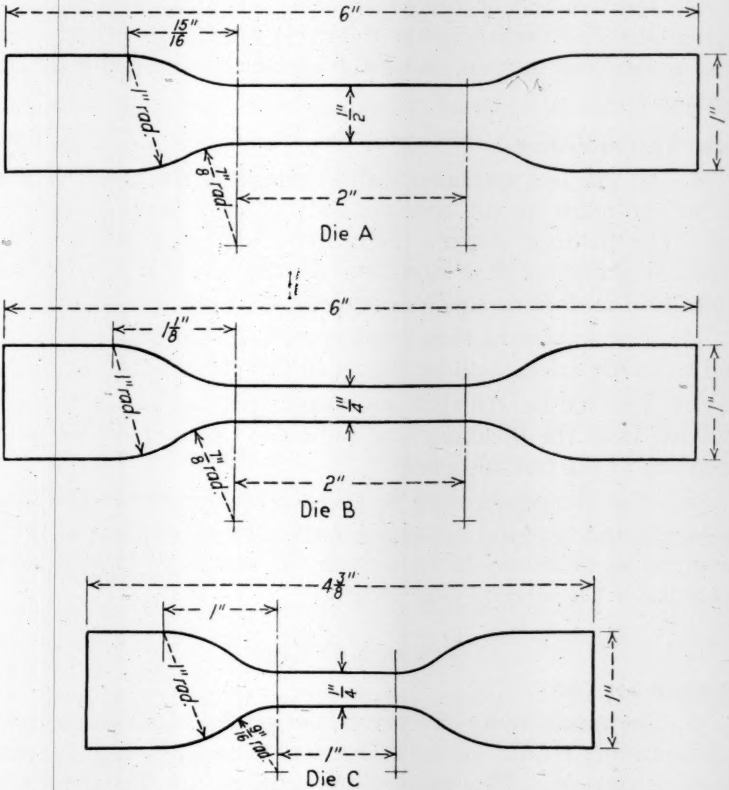

FIG. 1.—Tensile Strength and Elongation Test Specimens.

Die A shall be used when the size of the sample and the tension and stretch limits of the testing machine permit, with exceptions as explained below. If the tension limit is too high for the machine, use Die B. If the stretch is too high for the machine, use Die C. Die C shall also be used for samples which are too small for A or B. In all cases in which the sample and testing machine limitations permit a choice in die shapes, the die giving the highest test values shall be used, as such higher results will be nearer to the true value of the material.

(*c*) *Buffing.*—The specimen shall be buffed smooth to remove surface corrugations, irregularities, or excess thickness. Buffing shall be done without excessive heating and the test specimen shall be allowed to rest after buffing for at least ten minutes before being tested.

(*d*) *Marking.*—Parallel gage lines 1 or 2 in. apart, depending upon the die used, shall be marked on the test specimen at right angles to the longitudinal axis by means of an accurate stamp or bench marker. Care must be taken to make fine lines and to avoid injuring the specimen.

(*e*) *Measurement of Test Specimen.*—The thickness of the test specimen shall be the minimum thickness found between the marks on the constricted portion, using the standard micrometer described in Section 4 (*b*).

Tension Test Procedure

8. (*a*) The test specimen shall be placed in the jaws. The jaws shall be separated at the specified rate of speed until rupture takes place. The distance between the centers of the gage marks noted at the instant of rupture shall be measured using, a rule or tape graduated to eighths of an inch or smaller divisions.

(*b*) Test specimens that break outside of the gage marks or are found to be imperfect shall be discarded and retests shall be made.

(*c*) The tensile strength in pounds per square inch shall be calculated from the breaking load indicated by the machine and the dimensions of the test specimen.

(*d*) The elongation shall be the difference between the original gage length and the total distance between the gage marks at the time of rupture as measured in Paragraph (*a*) and shall be expressed in percentage of the original gage length.

PERMANENT SET[1]

Permanent Set Test

9. The specimen for the permanent set test shall be prepared as for determining tensile strength (Section 7) and placed in a suitable stretching device. The grips shall conform to the requirements specified in Section 6 (*b*). The specimen shall be stretched to an amount equal to three fourths of the ultimate elongation specified, held for 2 minutes, released, and measured at the expiration of 2 minutes. The difference between this measurement and the original gage length divided by the original gage length and expressed as a percentage shall be recorded as the permanent set. If no ultimate elongation is specified, the specimen shall be stretched an amount equal to three fourths of the elongation determined under Section 8.

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[1] The amount of permanent set is considered by many rubber technologists as having no relation to the service value of rubber compounds except for some specialized requirements. The permanent set test is, therefore, not recommended for general use.

ADHESION TESTS

Adhesion Test Specimen

10. The adhesion test specimen shall be cut transversely from the sample in a ring 1 in. in width with a sharp tool which will leave clean edges.

Adhesion Test Procedure

11. The test specimen shall be placed on a mandrel having a diameter equal to the nominal diameter of the hose. The parts to be tested shall be separated sufficiently by hand to permit attaching the jaws of a testing clamp. With the mandrel supported so that it may revolve freely with minimum friction, the prescribed weight shall be attached to the clamp with suitable provision for supporting and releasing it slowly without jerking. The average rate of separation shall not exceed 1 in. per minute. The separation shall be noted for a period of 4 minutes, unless the small size of the specimen makes a shorter period necessary.

Number of Tests and Retests

12. (*a*) When minimum requirements are established one test shall be made for tensile strength, elongation, permanent set and adhesion. If the results are below the specified requirements, two additional specimens shall be prepared from the original sample and tested. Should the results of either of these tests be below the specified requirements, the sample shall be considered to have failed to meet the specifications.

(*b*) If minimum requirements are not established, at least three tests shall be made and recorded for tensile strength, elongation, permanent set and adhesion.

HYDROSTATIC TEST FOR BURSTING STRENGTH

Hydrostatic Test Specimen

13. The specimen for the hydrostatic test shall be at least 18 in. in length for hose 3 in. and smaller in inside diameter, and at least 24 in. in length for larger hose.

Hydrostatic Test Procedure

14. The hydrostatic test for bursting strength shall be made by means of a hand or power-driven hydraulic pump or an accumulator system. The hose specimens shall be connected to the water line or pump and filled with water, allowing the air to escape. The pressure shall then be applied at a uniform rate of increase of approximately 1000 lb. per sq. in. per minute. Pressure shall be measured with a calibrated gage. The pressure shall be raised at the above rate until failure, and the pressure at which failure occurs shall be considered the bursting strength of the hose.

INSPECTION AND REJECTION

Inspection

15. (*a*) All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified. The manufacturer shall afford the inspector, without charge, all reasonable facilities to test and inspect the hose.

(*b*) The purchaser may make the tests and inspection to govern the acceptance or rejection of the material in his own laboratory or elsewhere. Such tests and inspection shall be made at the expense of the purchaser not later than 60 days after receipt of the material.

Retests and Rejection

16. (*a*) Any material which fails in one or more tests may be resampled and retested at the expense of the manufacturer. For this purpose two additional samples shall be selected from the hose for the test which failed to meet the requirements. Failure of either of the retested samples shall be cause for final rejection.

(*b*) Rejected material shall be returned to the manufacturer at his expense.

TENTATIVE METHODS OF TEST
FOR
RUBBER HOSE - WRAPPED CONSTRUCTION[1]

A.S.T.M. Designation: D 380 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1933.[2]

Scope

1. These methods shall be employed in the examination and test of rubber hose wherein part or all of the reinforcing fabric is woven prior to assembly in the hose. Hose constructed in this manner is known as wrapped hose.

Sampling

2. A sample of sufficient length for proper performance of the tests specified herein shall be cut from the hose. The pieces of hose from which samples have been cut shall be accepted by the purchaser as full length, provided the hose meets the specified requirements. In general, the amount required and the frequency of sampling for each size and type of wrapped hose shall be one 30-in. sample from 500 ft. or fraction thereof of hose over $1\frac{1}{4}$ in. in nominal diameter, and one 36-in. sample from 500 ft. or fraction thereof of hose $1\frac{1}{4}$ in. or under in nominal diameter.

Measurement of Hose

3. (*a*) *Length.*—The length shall be determined by means of a steel tape and shall not include length of fittings except when specifically so requested and recorded.

(*b*) *Outside Diameter.*—The outside diameter shall be determined by calculation from measurement of the outside circumference. A tape graduated to read the diameter directly may be used.

(*c*) *Inside Diameter.*—The inside diameter shall be measured with a plug gage on hose of 3 in. and under in nominal diameter. On larger hose, a steel scale or caliper may be used.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. Arthur W. Carpenter, Secretary of Committee D-11 on Rubber Products, The B. F. Goodrich Co., Akron, Ohio.

These tentative methods are in effect a revision of and replace the former Standard Specifications for Wrapped Air Hose for Use with Pneumatic Tools (A.S.T.M. **Designation:** D 46 - 24), **for Wrapped** Cold Water Hose (A.S.T.M. **Designation:** D 177 - 24) and the **Tentative Specifications for Steam** Hose (A.S.T.M. **Designation:** D 54 - 31 T), **which specifications were accordingly discontinued in 1933.**

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 16, 1933.

Thickness of Tube, Cover and Intermediate Layer

4. (*a*) The thickness of the tube, cover, intermediate layer and other component rubber parts shall be determined on the unbuffed portions taken from the hose.

(*b*) The thickness of the tube, cover and intermediate layer shall be determined by means of a micrometer graduated to thousandths of an inch and having a presser foot 0.25 in. ± 0.01 in. in diameter, exerting a total force of 9 oz. ± 0.1 oz. The load shall be applied by means of a weight.

Test Conditions

5. The temperature of the testing room shall be between 65 and 90 F. The samples to be tested shall be kept in this room for at least 30 minutes previous to the time of testing.

TENSILE STRENGTH AND ELONGATION OF RUBBER

Tension Test Apparatus

6. (*a*) *Testing Machine.*—Tensile strength and elongation tests shall be made on apparatus accurate within ± 1 per cent and provided with an accurate device for indicating the actual maximum load at rupture. The preferred type of apparatus is a power-driven machine of the inclination-balance or pendulum type, but a spring balance accurately calibrated may be used.

(*b*) *Grips for Testing.*—The grips for holding the test specimen shall be such that they tighten automatically, exerting a uniform pressure, proportional to the applied tension, across the full width of the enlarged end of the test specimen. The moving grip shall move at a constant speed of 20 in. per minute.

Tension Test Specimen

7. (*a*) *Separation of Rubber Parts.*—Sufficient length shall be cut from the hose sample to provide longitudinal tension test specimens from hose $1\frac{1}{4}$ in. and under in nominal diameter and transverse test specimens on larger sizes. The rubber parts to be tested shall be separated from the balance of the hose without the use of gasoline, if possible. If it is necessary to employ gasoline to effect the separation, it shall be of a grade distilling below 150 C. and which, upon evaporation, does not leave an appreciable amount of oily residue. After use of gasoline, the test specimen shall be allowed to rest at least an hour before testing.

(*b*) *Preparation of Specimen.*—The test specimen shall be stamped out from the separated rubber part with dies conforming to

Fig. 1 *A*, *B* or *C*. In no case shall the thickness of the test specimen exceed $\frac{1}{8}$ in. Test specimens shall be free from marked irregularities of thickness.

(*c*) *Buffing.*—The specimen shall be buffed smooth to remove surface corrugations, irregularities, or excess thickness. Buffing shall be done without excessive heating and the test specimen shall be allowed to rest after buffing for at least ten minutes before being tested.

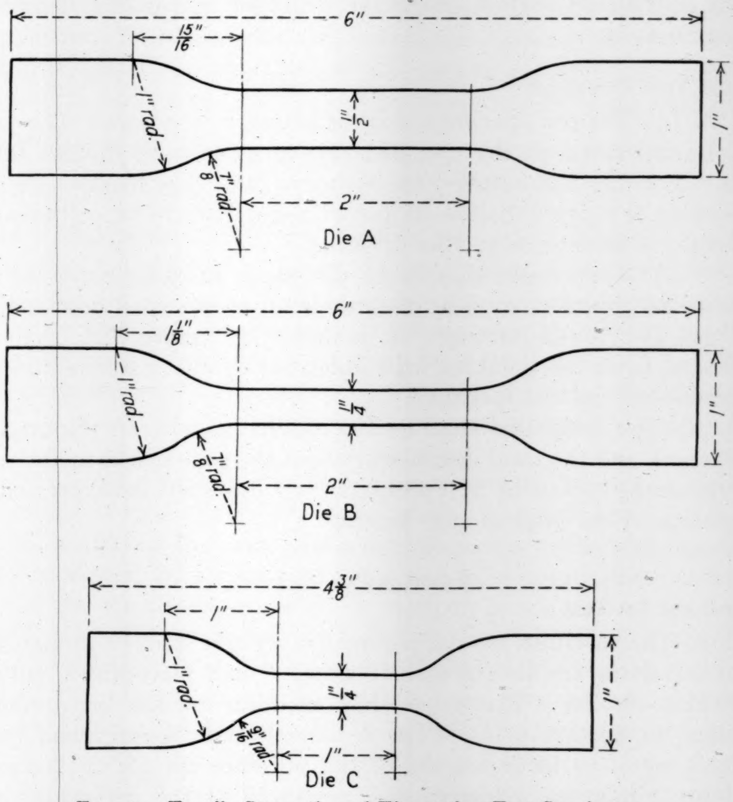

FIG. 1.—Tensile Strength and Elongation Test Specimens.

Die A shall be used when the size of the sample and the tension and stretch limits of the testing machine permit, with exceptions as explained below. If the tension limit is too high for the machine, use Die B. If the stretch is too high for the machine, use Die C. Die C shall also be used for samples which are too small for A or B. In all cases in which the sample and testing machine limitations permit a choice in die shapes, the die giving the highest test values shall be used as such higher results will be nearer to the true value of the material.

(*d*) *Marking.*—Parallel gage lines 1 or 2 in. apart, depending upon the die used, shall be marked on the test specimen at right angles to the longitudinal axis by means of an accurate stamp or bench marker. Care must be taken to make fine lines and to avoid injuring the specimen.

(*e*) *Measurement of Test Specimen.*—The thickness of the test specimen shall be the minimum thickness found between the marks on the constricted portion, using the standard micrometer described in Section 4 (*b*).

Tension Test Procedure

8. (*a*) The test specimen shall be placed in the jaws. The jaws shall be separated at the specified rate of speed until rupture takes place. The distance between the centers of the gage marks noted at the instant of rupture shall be measured, using a rule or tape graduated to eighths of an inch or smaller divisions.

(*b*) Test specimens that break outside of the gage marks or are found to be imperfect shall be discarded and retests shall be made.

(*c*) The tensile strength in pounds per square inch shall be calculated from the breaking load indicated by the machine and the dimensions of the test specimen.

(*d*) The elongation shall be the difference between the original gage length and the total distance between the gage marks at the time of rupture as measured in Paragraph (*a*) and shall be expressed in percentage of the original gage length.

PERMANENT SET[1]

Permanent Set Test

9. The specimen for the permanent set test shall be prepared as for determining tensile strength (Section 7) and placed in a suitable stretching device. The grips shall conform to the requirements specified in Section 6 (*b*). The specimen shall be stretched to an amount equal to three fourths of the ultimate elongation specified, held for 2 minutes, released, and measured at the expiration of 2 minutes. The difference between this measurement and the original gage length divided by the original gage length and expressed as a percentage shall be recorded as the permanent set. If no ultimate elongation is specified, the specimen shall be stretched an amount equal to three fourths of the elongation determined under Section 8.

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[1] The amount of permanent set is considered by many rubber technologists as having no relation to the service value of rubber compounds except for some specialized requirements. The permanent set test is, therefore, not recommended for general use.

ADHESION TESTS

Adhesion Test Specimens

10. The adhesion test specimen shall be cut transversely from the sample in a ring 1 in. in width with a sharp tool which will leave clean edges. On hose 4 in. and under in internal diameter the specimens shall be tested in ring form and shall be referred to as "ring specimens." For hose over 4 in. in internal diameter the rings shall be cut through at the point where the outside ply of fabric ends, and opened to form strips which shall be referred to as "strip specimens."

Adhesion Test Procedure

11. (*a*) *Ring Specimens.*—The ring specimen shall be placed on a mandrel having a diameter equal to the nominal diameter of the hose. The parts to be tested shall be separated sufficiently by hand to permit attaching the jaws of a testing clamp. With the mandrel supported so that it may revolve freely with minimum friction, the prescribed weight shall be attached to the clamp with suitable provision for supporting and releasing it slowly without jerking. The average rate of separation shall not exceed 1 in. per minute. The separation shall be noted for a period of 4 minutes, unless the small size of the specimen makes a shorter period necessary.

(*b*) *Strip Specimens.*—The various parts to be tested shall be separated at one end of the strip specimen a sufficient distance to permit attaching the jaws of the testing clamp. The strip specimen shall be suspended by the separated end, all separate parts of which, except the one under test, shall be clamped in the jaws of the testing clamp. A minimum weight sufficient to maintain the strip specimen in approximately a vertical position shall be attached to the lower end of the test specimen, or the specimen may be held against a vertical plate in such a manner as to hold the specimen in approximately a vertical position during the test. The specified weight shall be applied to the separated end with suitable provision for releasing it slowly without jerking. The average rate of separation shall not exceed 1 in. per minute. The separation shall be noted for a period of 4 minutes.

Number of Tests and Retests

12. (*a*) When minimum requirements are established one test shall be made for tensile strength, elongation, permanent set and adhesion. If the results are below the specified requirements, two additional specimens shall be prepared from the original sample and tested. Should the results of either of these tests be below the specified requirements, the sample shall be considered to have failed to meet the specifications.

(*b*) If minimum requirements are not established, at least three tests shall be made and recorded for tensile strength, elongation, permanent set and adhesion.

HYDROSTATIC TEST FOR BURSTING STRENGTH

Hydrostatic Test Specimen

13. The specimen for the hydrostatic test shall be at least 18 in. in length for hose 3 in. and smaller in inside diameter, and at least 24 in. in length for larger hose.

Hydrostatic Test Procedure

14. The hydrostatic test for bursting strength shall be made by means of a hand or power-driven hydraulic pump or an accumulator system. The hose specimens shall be connected to the water line or pump and filled with water, allowing the air to escape. The pressure shall then be applied at a uniform rate of increase of approximately 1000 lb. per sq. in. per minute. Pressure shall be measured with a calibrated gage. The pressure shall be raised at the above rate until failure, and the pressure at which failure occurs shall be considered the bursting strength of the hose.

INSPECTION AND REJECTION

Inspection

15. (*a*) All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified. The manufacturer shall afford the inspector, without charge, all reasonable facilities to test and inspect the hose.

(*b*) The purchaser may make the tests and inspection to govern the acceptance or rejection of the material in his own laboratory or elsewhere. Such tests and inspection shall be made at the expense of the purchaser not later than 60 days after receipt of the material.

Retests and Rejection

16. (*a*) Any material which fails in one or more tests may be resampled and retested at the expense of the manufacturer. For this purpose two additional samples shall be selected from the hose for the test which failed to meet the requirements. Failure of either of the retested samples shall be cause for final rejection.

(*b*) Rejected material shall be returned to the manufacturer at his expense.

TENTATIVE SPECIFICATIONS
FOR
ASBESTOS ROVING[1]

A.S.T.M. Designation: D 375 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1933.

Scope

1. These specifications cover an asbestos textile product to be used as insulation on heat-resisting fixture wire, flexible cord or heater cord, and similar electrical conductors.

Roving

2. Roving, in the asbestos textile industry, is an assemblage of carded fibers rubbed into a single strand without twist.

Types

3. (*a*) *Asbestos Roving.*—Asbestos roving is composed of a mixture of chrysotile asbestos and cotton or other vegetable fiber.

(*b*) *Reinforced Asbestos Roving.*—Reinforced asbestos roving is composed of a core of cotton yarn covered with a mixture of chrysotile asbestos and vegetable fiber.

Grade

4. Standard grade asbestos roving may have a carbon content of not more than 10 per cent.

NOTE.—This requirement, which conforms to the Underwriters' Laboratories requirements, is met by grade A asbestos yarn of the Standard Specifications for Asbestos Yarns (A.S.T.M. Designation: D 299) of the American Society for Testing Materials.[2]

Varieties

5. Roving shall be made in two varieties, ferrous and non-ferrous.

Iron Content

6. (*a*) *Ferrous Roving.*—The total iron content of ferrous roving

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. W. H. Whitcomb, Secretary of Committee D-13 on Textile Materials, Interlaken Mills, West Warwick, R. I.

[2] 1933 Book of A.S.T.M. Standards, Part II, p. 1161.

shall not exceed 6 per cent and the magnetic iron content shall not exceed 2 per cent of the weight of the dried sample.

(*b*) *Non-Ferrous Roving.*—The total iron content of non-ferrous roving shall not exceed 1.75 per cent and the magnetic iron content shall not exceed 0.75 per cent of the weight of the dried sample.

Sizes

7. The standard sizes of asbestos roving, designated as "cut," shall conform to the following requirements:

SIZE DESIGNATION	NOMINAL YARDAGE PER POUND	PERMISSIBLE VARIATION IN YARDAGE
5-cut	500	450 to 549
6-cut	600	550 to 649
7-cut	700	650 to 749
8-cut	800	750 to 849
9-cut	900	850 to 949
10-cut	1000	950 to 1049
12-cut	1200	1150 to 1249
14-cut	1400	1300 to 1499

NOTE.—The tolerances on special sizes such as 5½-cut, 6½-cut, etc., shall be equal to those of the standard sizes.

METHODS OF TESTING

Yards per Pound

8. Six cones, tubes or cheeses of roving shall be taken at random and five determinations of the number of yards per pound made on each package selected. The packages shall be grouped on the floor and six strands shall be drawn from them slowly, looping over a support to assemble 24 strands, which shall be cut into a 1-yd. length while suspended. The 24 yards shall be weighed to the nearest grain and the number of yards per pound calculated.

Asbestos and Carbon Determination

9. (*a*) A 1-oz. sample shall be dried to constant weight in a weighed crucible at 212 F. (100 C.). The dried sample shall then be ignited in an electric furnace at 1600 F. (871 C.) for 1 hr., and then cooled to room temperature in a desiccator and weighed. The weight of ash shall be divided by the factor 0.86[a] to obtain the original weight of the asbestos fiber. To obtain the percentage of asbestos, divide the weight of asbestos by the weight of the dried sample. To obtain the percentage of carbon, divide by 2.25 the difference between 100 per cent and the percentage of asbestos.

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[a] This factor is based on a proved average of 14 per cent water of crystallization in chrysotile asbestos.

(*b*) Asbestos and carbon determinations of reinforced asbestos roving shall be made in accordance with Paragraph (*a*) after removing the cotton thread.

Iron Determination

10. (*a*) The total iron content shall be determined by the potassium dichromate oxidation method.

(*b*) The percentage of magnetic iron shall be determined by the Mapes method.[1]

PACKING

Packing

11. Asbestos roving shall be supplied in the following three styles and dimensions of packages, the "cheese," the cone and the tube:

(*a*) *Cheese.*—Dimensions of the "cheese" packages shall be approximately 8 in. in outside diameter, 1½ in. in inside diameter and 2¼ in. in thickness.

(*b*) *Cone.*—The standard paper cone shall conform approximately to the following dimensions:

Inside diameter at base	1⅞ in.
Inside diameter at top	7/16 in.
Length	4½ in.
Thickness	⅛ in.
Diameter of winding at base	4½ in.
Traverse	4¼ in.

(*c*) *Tube.*—The standard paper tubes in two sizes shall conform approximately to the following dimensions:

Length, in	2¾	4¼
Inside diameter, in	1⅛	⅝
Thickness, in	⅛	⅛
Diameter of winding, in	4½	2½
Traverse, in	2½	4

Wrapping

12. All packages shall be individually wrapped in soft paper.

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[1] *Asbestos*, p. 19, October, 1932.

TENTATIVE SPECIFICATIONS
FOR
HOLLAND CLOTH[1]

A.S.T.M. Designation: D 376 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1933.

Scope

1. These specifications cover No. 1 and No. 2 constructions of Holland cloth for use in the tire industry.

Properties

2. Holland cloth shall conform to the requirements specified in Table I, subject to the tolerances specified therein.

TABLE I.—PHYSICAL PROPERTIES OF HOLLAND CLOTH.

		No. 1 Construction	No. 2 Construction	Tolerances No. 1 and No. 2 Constructions
Width (trimmed), in.		as specified	as specified	±$\frac{1}{4}$
Weight, oz. per sq. yd.		4.8	4.6	±0.2
Count	Warp	74	56	±4
	Filling	64	46	±4
Thickness (Gage), in.		0.005	0.0045	±0.0005
Length of Roll, yd.		300	300	±30

Tolerances

3. Tolerances shall be the limits within which a textile must come in its specified characteristics in order that it shall constitute a good delivery on contract. They may be classified as the allowable limits of the quantitative characteristics of the fabric as defined in the specifications.

SPECIAL REQUIREMENTS

Defects

4. Holland cloth shall have a smooth surface, shall not bag in the center, shall not have loose or wavy edges, shall not be cockled or wrinkled, or have any other defects which will mar the fabric or interfere with recognized factory processes.

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[1] **Criticisms** of these Tentative Specifications **are solicited and should be directed to Mr. W. H. Whitcomb, Secretary** of Committee **D-13** on Textile **Materials, Interlaken Mills, West Warwick, R. I.**

Porosity

5. Holland cloth shall contain no pinholes or pores through which rubber will pass when under pressure.

Finish

6. The finish shall be smooth and shall not flake when subjected to recognized factory test. Rejection for finish shall be made within 30 days of receipt of material.

Splices

7. Splices shall not be more than 4 in. in width and shall be strong enough to resist pulling apart at any point. Calendered splices shall be used unless otherwise specified.

Selvage

8. Holland cloth shall be trimmed on both edges so that no selvage is present.

Shells

9. Shells shall consist of heavy paper tubes $\frac{3}{16}$ in. in thickness and $1\frac{1}{4}$ in. in inside diameter, unless otherwise specified.

Roll Edges

10. Each roll shall be tightly and evenly wound so that both edges are even throughout.

Wrapping

11. Rolls shall be wrapped with moisture-proof paper and sealed in a manner that protects the material from excess moisture in the air.

Packing

12. Rolls shall be packed in a suitable container and in a manner that will prevent slippage of the material on itself or damage to the edges. Containers shall be of such size as to hold approximately 1200 yd. of material, or four rolls.

Length of Cuts or Pieces

13. No roll shall contain more than three splices and no piece shall be less than 15 yd. in length.

Shortage

14. Shortage in excess of 0.5 per cent of the total billed yardage of any shipment will be charged back to the shipper at full contract price.

METHODS OF TESTING

Width

15. The average width shall be determined by measuring at five different places uniformly distributed along the full length of the roll or piece. No measurement shall be considered within 3 yd. of either end of the roll or piece.

Weight

16. The weight per square yard shall be determined in accordance with Sections 3 and 7 of the Standard General Methods of Testing Woven Textile Fabrics (A.S.T.M. Designation: D 39) of the American Society for Testing Materials.[1]

Count

17. The average number of ends and picks per inch of the fabric shall be determined by counting a space not less than 1 in. in five different places uniformly distributed along the full length of the roll or piece. No count shall be considered within 3 yd. of either end of the roll or piece, or within 6 in. of the edge of the roll or piece.

Thickness (Gage)

18. The average thickness of the fabric shall be determined by means of an automatic micrometer equipped with a foot $\frac{3}{8}$ in. in diameter. The foot of the micrometer shall be raised $\frac{1}{4}$ in. above the fabric and allowed to drop under a dead weight pressure of 6 oz. Thickness measurements shall be made in five different places uniformly distributed along the full length of the roll or piece. No determination shall be considered within 3 yd. of either end of the roll or piece or within 6 in. of the edge of the roll or piece.

Length of Roll

19. The length of a roll or piece shall be determined by running the cloth over a measuring drum of known circumference, from which the yardage is registered by a dial or counter driven by a chain, or other positive or non-slip mechanism. Just enough uniform tension shall be used on the cloth to keep it running flat and true.

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[1] 1933 Book of A.S.T.M. Standards, Part II, p. 1224.

TENTATIVE METHODS OF TEST
FOR
SMALL AMOUNTS OF COPPER AND MANGANESE IN TEXTILES[1]

A.S.T.M. Designation: D 377 – 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1933.

Test Samples

1. The samples for analysis shall be as fairly representative of the material as possible. An individual test sample should preferably weigh approximately 10 g., but in any case, shall weigh not less than 5 g.

Blanks

2. Blank tests shall be run on all determinations and deductions made accordingly.

Number of Tests

3. A minimum of three determinations shall be made in every case and the average value taken as the true value. In cases of dspute an average of at least five determinations shall be taken.

Reagents

4. All reagents shall be of c.p. quality as prescribed by the American Chemical Society.

DETERMINATION OF COPPER

Reagents Required

5. The following reagents will be required:

(*a*) *Standard Copper Solution.*—Electrolytic copper foil of known purity shall be used for the preparation of the standard solution. The foil shall be cleaned by scraping down to the bright metal. Exactly 1 g. shall be dissolved in an Erlenmeyer flask in the least required amount of a solution of one volume of concentrated HNO_3 to one-half volume of distilled water. Approximately 10 ml. of this diluted acid will be required. After solution, with full use of heat until brown fumes are no longer apparent to the eye, 30 ml. of distilled water and a small amount (approximately 1 g.) of pure powdered talcum shall be added. The mixture shall then be boiled vigorously for at least 10 minutes. The escaping vapors, when not too strongly acid, may be tested for nitrous acid with moist starch iodide paper. Boiling under these conditions should quickly give a negative test and need not be continued to dryness. After cooling, enough distilled water shall be added to bring the volume up to approximately 100 ml. The talc shall then be filtered off on an asbestos-padded Gooch crucible and washed thoroughly with hot distilled water. The entire filtrate with washings shall be transferred to a 1-liter volumetric flask and, after cooling to 25 C., shall be made up to the mark with distilled water. The strength of this solution may be checked by electrolytic determination of the copper in tartrate-cyanide solution on a platinum dish cathode.[1]

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. W. H. Whitcomb, Secretary of Committee D-13 on Textile Materials, Interlaken Mills, West Warwick, R. I.

In a volumetric flask, 10 ml. of the standard copper solution shall be diluted to 1 liter with copper-free distilled water at 25 C. One milliliter of this solution is equivalent to 0.00001 g. of copper.

(*b*) *Thiosulfate Solution.*—A solution of sodium thiosulfate of approximately 0.001 *N* strength shall be used. A standard solution of approximately 0.1 *N* strength shall first be prepared by dissolving about 25 g. of the crystalline sodium thiosulfate ($Na_2S_2O_3 \cdot 5H_2O$) and 2 g. of sodium hydroxide in 1 liter of distilled water. In a volumetric flask, 10 ml. of the 0.1 *N* sodium thiosulfate solution shall be diluted to 1 liter with distilled water. The 0.001 *N* sodium thiosulfate solution shall be standardized by taking an amount of the standard copper solution approximately equivalent to the amount of copper expected in the sample and treating it as outlined in the determination of copper, starting with the addition of 10 ml. of concentrated HCl, Section 6. The 0.001 *N* sodium thiosulfate solution is not very stable and shall be freshly prepared each day from the 0.1 *N* solution.

(*c*) *Starch Indicator Solution.*—This solution shall contain approximately 10 g. of soluble starch per liter of water. The water shall be boiled and the starch dissolved by adding it slowly with rapid stirring to the boiling solution. The starch solution shall be freshly prepared every two to three days.

(*d*) *Bromine Water.*—The bromine water shall be made by adding an excess of bromine to distilled water, without adding a soluble bromide to increase its concentration. The presence of a soluble bromide leads to the formation of compounds of the nature of hypobromites which will liberate iodine and cause the results to be high.

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[1] A. W. Peters, "A Simple and Rapid Method of Electrolysis of Copper Solutions with Tartrate Cyanide Electrolyte," *Journal*, Am. Chemical Soc., Vol. 34, p. 426 (1912).

Method of Analysis

6. *Ashing.*—The accurately weighed sample shall be cut into small pieces and placed in a No. 00A porcelain evaporating dish of 10-ml. capacity. The dish shall be placed on a Chromel triangle over a low flame from a bunsen burner protected from strong drafts. Care shall be taken not to allow the material to catch fire. The best condition is after the fiber has distilled off leaving a carbonaceous skeleton. At this point the dish shall be allowed to cool and the residue shall be moistened carefully with five drops of concentrated HNO_3 and one drop of concentrated H_2SO_4. The heat shall again be applied gradually and raised until all carbon and tarry residue is burned off. The time consumed in ashing is usually about 20 minutes.

7. *Titration.*—The ash shall be dissolved in 10 ml. of concentrated HCl by heating on a hot plate for 10 minutes and then transferred to a beaker with 50 ml. of hot distilled water. Approximately 2 to 5 ml. of bromine water shall be added and the solution shall be boiled briskly until the excess bromine has been boiled off. In order to insure the complete removal of the bromine it is necessary to boil the solution down to about one third its original volume. The solution shall be cooled slightly and concentrated NH_4OH added in slight excess. The solution shall then be boiled vigorously for a few minutes in order to coagulate the iron precipitate, expel the excess of ammonia, and destroy compounds which may be formed if all the bromine has not been expelled. The iron precipitate shall be filtered off through a thin asbestos mat and washed three or four times with a little hot distilled water. Dilute acetic acid shall then be added to the filtrate until the blue color just disappears or until the solution is just faintly acid to litmus paper. The solution shall then be heated to boiling for a few minutes more, cooled to tap water temperature, and 5 g. of potassium iodide (free from iodate) or an equivalent amount of a freshly prepared solution of potassium iodide shall be added. One milliliter of starch indicator shall be added and the solution shall be titrated immediately with 0.001 *N* sodium thiosulfate. It is necessary to stir the solution vigorously when titrating with the 0.001 *N* solution because diffusion is slower with such a dilute solution. It is advisable to titrate as quickly as possible to the end point. With some samples, if allowed to stand exposed to the air, a blue color will reappear after the titration is completed. This may be disregarded since an end point, permanent for 1 minute, indicates that all of the copper has been titrated.

DETERMINATION OF MANGANESE

Method of Analysis

8. *Digestion.*—The accurately weighed sample shall be placed in a 300-ml. Kjeldahl flask. To the sample shall be added 25 ml. of concentrated HNO_3, then 25 ml. of concentrated H_2SO_4 added carefully, and 5 g. of anhydrous sodium or potassium sulfate. The digestion will at first proceed vigorously with very little heating. When the action slows down, the flask shall be clamped in position over a large Meker burner so that the bottom of the flask shall not be over ½ in. from the top of the burner, allowing the flame to strike the bare flask. This digestion shall be carried out in a hood with a good draft. Using the full heat of the burner, the sample shall be digested in this manner until a clear melt of 2 to 5 ml. is obtained. In the case of animal fibers, if the mass dries before becoming entirely clear, 15 ml. each of HNO_3 and H_2SO_4 shall be added carefully and the procedure just described shall be repeated. For cotton and rayon samples this digestion can be completed within 30 minutes. For wool or silk 1 hr. is the maximum time that is necessary.

9. *Analysis.*—The clear melt shall be taken up with about 50 ml. of distilled water and made slightly alkaline with concentrated NH_4OH. Dilute acetic acid shall then be added until the solution is just faintly acid to litmus paper. Then 20 ml. of 85 per cent phosphoric acid and 0.5 g. of potassium periodate shall be added and the solution boiled for 10 minutes to convert the manganese to permanganate. It shall then be cooled, diluted to 100 ml. in a Nessler tube, and compared with a series of standards of known permanganate content.

10. *Standards.*—The standards shall be prepared from definite amounts of some pure manganese salt by treatment with phosphoric acid and potassium periodate in the same manner as described in Section 9.

TENTATIVE METHODS FOR THE IDENTIFICATION OF FIBERS IN TEXTILES AND FOR THE QUANTITATIVE ANALYSIS OF TEXTILES[1]

A.S.T.M. Designation: D 276 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

Issued, 1927; Revised, 1929, 1930, 1931, 1933.

METHODS FOR THE IDENTIFICATION OF FIBERS IN TEXTILES

Successful identification of the fibers used in textiles depends upon experience and familiarity with the fibers. The ultimate test of the diagnosis of an unknown is comparison with a known standard sample. It is not only desirable but necessary for the analyst to have authentic samples of the fibers likely to occur in the textiles he is called upon to analyze.

The key used in these methods is not concerned with describing the fiber but rather with pointing out for each group of fibers and finally, within the group, for each fiber, that particular characteristic or group of characteristics by which the fiber differs from similar fibers. Often this is a minor detail of structure, or staining reaction. Occasionally, it is somewhat subjective, but an effort has been made to choose objective characteristics which will be evident to all observers. For the benefit of those unfamiliar with the use of a key it should be said that the arrangement is necessarily artificial. Groups are established on the basis of similarity and dissimilarity for convenience only, and without regard for chemical, biological or industrial relationships.

The "keying out" of an unknown is simply a matter of elimination. In every division and subdivision of the key there are *two alternatives* both numbered or lettered alike. It is necessary to *reject* one and to *accept* the other as descriptive of the fiber in question. It is quite possible that neither phrase exactly describes the fiber, but it is necessary to make the best choice between the two and to follow through the entire key, step by step, in the same manner. A decision should never be made as to which group the fiber belongs until both descriptions under that designation have been considered. Except where definitely stated, descriptions are of ultimate fibers rather than of "technical" fibers or fiber aggregates. For adequate study of these a microscope is necessary, and for analytical purposes a magnification of 100 diameters is most satisfactory.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. W. H. Whitcomb, Secretary of Committee D-13 on Textile Materials, Interlaken Mills, West Warwick, R. I.

The technique of mounting fibers for microscopical examination is relatively simple, but experience brings proficiency and speed. To remove dyes, natural or applied oils, starch, sizing, and other materials it is advisable to begin by heating the fibers in a dilute solution of caustic soda (0.5 per cent). Because wool and hair are quickly disintegrated in hot caustic, care shall be taken to shorten the cooking in such cases. In examining fabrics this step is often not necessary. In vegetable fibers prolonged boiling is beneficial in breaking up the fiber bundles and larger aggregates so that the ultimate cells can be separated. Since most stains are indicators, it is necessary that all caustic be washed from the sample before proceeding further with the tests. Rubbing and squeezing between the fingers under running tap water is sufficient. Small samples of the fiber shall be placed on a slide and teased apart with needles. Too much material on one slide renders adequate separation difficult. It cannot be too strongly emphasized that a just and impartial consideration of the material must be based on single fibers and their minute configurations rather than on a confused mass of fibers. Moreover, several small samples taken at random from various regions of the material give more representative results than a single sample. Most stains take better if excess moisture has been blotted from the fiber with filter paper. To be sure that all fibers are stained equally they shall be stirred on the slide with needles. The most satisfactory examination of stained fibers is by transmitted light. Constant adjustment of the focus discloses the lumen and other structural features which may otherwise escape notice; and decreasing the intensity of the light by means of diaphragm or condenser adjustment is sometimes a revealing manipulation. It is worth while to notice extraneous materials which occur with the fiber. The presence or absence of epidermal cells, spirals, hairs, unusual configurations in cell groups or fiber bundles is often a clue when other features are less distinct than usual. An experienced fiber analyst has always in mind certain associations which though of no technical value, are to him, personally, dependable means of identification.

REAGENTS

The following reagents will be required:

Aniline Sulfate

Aniline sulfate	1 g.
Distilled water	100 ml.
Sulfuric acid (10 per cent solution)	1 ml.

Hemp stains yellow; linen is unstained.

Diphenylamine Solution

Concentrated H_2SO_4	20 ml.
Glacial acetic acid	10 ml.
Diphenylamine	0.3 g.

Hahn's Solution

Solution A:

Picric acid	1 g.
Distilled water	100 ml.

Solution B:

Soluble Blue 2B Extra (Color index 707)	0.2 g.
Eosin (Color index 768)	0.1 g.
Tannic acid	1.0 g.
Distilled water	100 ml.
Hydrochloric acid (10 per cent solution)	0.2 ml. (when solution has cooled)

Mix solutions *A* and *B* in equal parts for rayon tests.

Herzberg's Solution

Solution A:

Zinc chloride	50 g.
Distilled water	25 ml.

Specific gravity at 28 C. should be 1.8

Solution B:

Potassium iodide	5.25 g.
Iodine	0.25 g.
Distilled water	12.5 ml.

Add solution *B* to solution *A*, stir; let stand overnight; decant from sediment; add a leaf of iodine; keep in dark bottle.

A good general stain for all fibers. Linen, cotton, hemp, ramie are stained red; jute, phormium, sisal and other lignified fibers, yellow. De-lignified fibers and cellulose cells are stained blue.

Herzog's Cyanin

Saturated alcoholic solution of Cyanin Blue (Color Index 288)	80 ml.
Distilled water	10 ml.
Concentrated glycerine	30 ml.

Apply hot to fibers; mount fibers in concentrated glycerine. Flax fibers are unstained; hemp fibers are blue.

Millon's Reagent

Dissolve mercury in an equal weight of cold fuming HNO_3 (sp. gr. 1.4), then apply moderate heat.

Dilute solution with 2 volumes of water.

Picric Acid

Picric acid	1 g.
Distilled water	100 ml.
Sodium hydroxide	0.5 g.

Brings out surface scales on animal fibers, especially wool and mohair.

ABRIDGED KEY FOR COMMON FIBERS

The fibers commonly met in textile fabrics are cotton, linen, jute, rayon, silk and wool. A few simple tests will identify these, but it is advisable to confirm the diagnosis by other tests rather than to rely on one identification only.

A. As a preliminary test, burn a few individual fibers by applying a flame to their ends.

Odor of burned feathers or hair; knob forms on end of fiber........*Silk or Wool* (see *a*).
Odor of burned feathers or hair; ash retains shape of thread........*Weighted Silk* (see *a*).
Distinctly aromatic odor, somewhat acrid; knob forms on end of thread........*Acetate Rayon* (see *b* and *c*).
Odor of burned paper or straw; ash shapeless; drops off........*Other Rayons, Cotton, Linen or Jute.*

B. Immerse fibers in an aqueous solution of caustic soda (0.5 per cent) and bring the solution to a boil. Wash thoroughly by squeezing and rubbing between the fingers under running tap water. Tease the fibers apart on a slide, blot off water with filter paper. Stain with a few drops of Herzberg's solution. Examine under magnification of 100 diameters.

1. Fibers yellow, white or greenish........2.
  2. Fibers distinctly pointed at ends, with narrow lumen; bright golden yellow........*Jute.*
  2. Fibers of indeterminate length, with cut ends........3.
    3. Fibers fine, sometimes flattish, of varying diameters, transparent, without cellular structure........4.
      4. Fibers with longitudinal striations, and sometimes with paired parallel lines in a diagonal direction (imprint of one fiber across another)........*Wild* (*Tussah*) *Silk* (see *a*).
      4. Fibers with fine diameters, without markings........*Cultivated Silk* (see *a*).
    3. Fibers larger, rod-shaped, with prominent scales........*Wool* (see *a* and *d*).
1. Fibers reddish or purple........5.
  5. Fibers cylindrical, pointed at ends, with cross marks on surface; swollen nodes, and narrow lumen........*Linen* (see *e*).
  5. Fibers lacking above characteristics........6.
    6. Fibers flat, more or less ribbon-like, frequently twisted, with broad lumen........*Cotton* (see *e*).
    6. Fibers without any lumen, straight........*Rayon* 7.
      7. Fibers with distinct longitudinal striations on the surface........*Viscose.*
      7. Fibers without striations........8.
        8. Stain with Hahn's solution. Fibers pink........*Nitrocellulose Rayon* (see *f*).
        8. Fibers not pink........9.
          9. Fibers yellow........*Cellulose Acetate Rayon* (see *b* and *c*).
          9. Fibers blue or colorless........*Cuprammonium Rayon* (see *g*).

(*a*) Millon's reagent colors true silk fibers (or other animal fibers such as wool, mohair or fur) pink. Vegetable fibers are not stained.

(*b*) Cellulose acetate rayon is dissolved in acetone; other fibers are not affected.

(*c*) Cellulose acetate rayon is dyed yellow in picric acid; other rayons wash out white.

(*d*) Surface markings, scales, etc., on wool fibers become more pronounced when fibers are stained with 1 per cent picric acid containing sodium hydroxide.

(*e*) Untwist the thread until a single dry fiber is exposed. Moisten the tip between thumb and finger; observe with a hand lens, as follows:

Fiber tip curls clockwise........................linen.
Fiber tip curls counter-clockwise................cotton.

(*f*) Nitrocellulose rayon dissolves to give a deep blue coloration when tested dry with a solution of diphenylamine in sulfuric acid.

(*g*) Cuprammonium rayon is dyed deep orange in 0.2 per cent solution of Erie Fast Orange C. G. (Color index 621); other rayons are white or weak orange.

ANALYTICAL KEY FOR IDENTIFICATION OF FIBERS

Touch end of fiber to a flame:

Fiber does not burn..........................Mineral Origin I.
Fiber burns with characteristic odor of burning feathers or glue..............................Animal Origin II.
Fiber burns with characteristic odor of burning paper or straw..............................Vegetable Origin III.

I. Fibers of Mineral Origin:

Asbestos, confirm by microscopical examination.

II. Fibers of Animal Origin:

1. **Fibers** coarse, more or less shiny, wiry; usually found in brushes or upholstery............................2.
  2. **Fibers** with diameters tapering from base to tip.......*Bristles* 3.
    3. **Bristles** dark, with pronounced white band short distance back of tip; tips not flagged..........*Badger Bristle.*
    3. **Bristles** same color throughout, with a knob frequently visible at butt ends where hair was pulled from follicle; tips flagged..............*Hog Bristle* 4.
      4. **Bristles** hardly more than $1\frac{1}{2}$ in. in length; varicolored; frequently curved; irregular as to length and diameter......................*Domestic Hog Bristle.*
      4. **Bristles** longer than $1\frac{1}{2}$ in., of rather uniform length, *straight*..........................5.
        5. **Bristles** all white, or chalk white............*Bleached* (*"French"*) *Bristle.*
        5. **Bristles** black, yellow, or grey (black and yellow mixture)........................6.
          6. Bristles 4 in. or longer, stiff, coarse, much flagged, usually grey or yellow........*Russian Bristle.*
          6. Bristles all black, 4 in. or shorter..........*Chinese* 7.

7. Bristles black, rather soft, often with flagged end clipped off............*Chungking Bristle.*

7. Bristles with flagged ends never clipped.8.

8. Bristles very fine, soft, usually not over 3 in....................*Tientsin Bristle.*

8. Bristle not so fine, longer...........*Hankow Bristle.*

2. Fibers with rather regular diameters throughout; little or no taper; tips not flagged; hair follicle knobs seldom present......................................*Hair* 9.

9. Hairs wiry, all black...........................10.

10. Hairs of average diameter of not less than 0.0055 in. (based on microscopical measurement of at least 100 hairs)..........................*Horsetail Hair.*

10. Hairs of average diameter less than 0.0055 in......*Horse Mane Hair.*

9. Hairs usually white, yellow or brown.................11.

11. Hairs smooth, scales scarcely visible..........12.

12. Hairs, smooth, roundish, showing under magnification of 100, distinct pigmentation, not isolated in a medulla, but scattered in lumpy streaks...........*Horsehair* (see 10).

12. Hairs less smooth, exhibiting less "character" than the above; showing under magnification of 100, distinct medulla with pigment closely packed in flat, accordion-like masses................*Cattle Hair.*

11. Hairs coarse with prominent surface scales, wide medulla filled with pigment, but not packed in any characteristic arrangement........*Goat Hair.*

1. Fibers fine, soft, more or less silky; from soft brushes, or from felts and fabrics...........................13.

13. Fibers fur-like...........................14.

14. Fibers showing pigmentation in wide medulla with regularly spaced blocks of pigment (×100).................15.

15. Hairs rather short, with pigment blocks in 1 or 2 rows..................*Common Rabbit.*

15. Hairs abnormally long, showing more than 2 rows of pigment blocks....*Angora Rabbit.*

14. Fibers showing pigment tightly packed in wide medulla, in irregularly checked mass...........................*Squirrel.*

13. Fibers filamentous 16.

16. Fibers rod-shaped with medullary canals, and scaly surfaces (×100)...17.

17. Fibers tan, brown or black........18.

18. Fibers with distinctly granular pigmentation and indistinct hollow medulla......*Alpaca.*

18. Fibers with no distinct medulla except in kemps where medulla is large and heavily pigmented...........*Camel Hair.*

17. Fibers usually white........................19.
19. Fibers with fine scales closely appressed to fiber surface; diameter usually small..*Mohair.*[1]
19. Fibers of various diameters, scales coarser, more loosely arranged..............*Wool.*
16. Fibers flat, smooth, transparent, void of cellular structure..................................20.
20. Fibers broad, varying in diameter, marked with longitudinal striations, and frequently with parallel diagonal lines where one fiber crossed over another has left an impression......................*Wild (Tussah) Silk.*
20. Fibers single, narrow, without striations..........................*Cultivated Silk.*

III. Fibers of Vegetable Origin:

For convenience these are grouped according to their uses as: *A. Brush Fibers*, *B. Cordage Fibers*, and *C. Vegetable Fibers from Fabrics.*

A. Brush Fibers[2]

1. Fibers hair-like, or rope-like, white, yellow (or dyed).....*Tampico.*[3]
1. Fibers more woody than hair-like......................2.
2. Fibers dark brown or black........................3.
3. Fibers thick, more or less circular, corky in texture..*Rattan.*
3. Fibers not corky, but woody....................4.
4. Fibers thin, wiry, circular....................*Bassine.*
4. Fibers thicker, flatter, more woody, brittle.......*Bass.*
2. Fibers reddish, wiry.............................*Palmetto.*

B. Cordage Fibers

Apply Swett's test as follows:

Wash sample in alcohol to remove grease. Immerse in nascent chlorine solution for 30 seconds. Wash in tap water; rinse in alcohol to remove water. Hold over concentrated ammonium hydroxide. Fumes produce:

Cherry red color ....Sisal and other rope fibers.
Brown color..............................Manila fibers.

1. Fibers brown or yellow...............................*Abaca* (Manila).[4]

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[1] Scales may be brought out distinctly by staining with picric acid.

[2] The term "fiber" is here used in its technical sense, meaning not the ultimate fiber cell, but rather a bundle or an aggregate of fibers.

[3] Sisal, palma, istle, henequen and other agaves.

[4] Confirm by microscopical examination for broad lumen.

1. **Fibers cherry red or pink**..........................2.

2. **Treat fibers in boiling dilute caustic, wash, separate into ultimate cells; stain with Herzberg's solution, examine under magnification of 100. Fibers yellow**..........................3.

3. Fibers more or less rounded at ends, diameters regular, fiber surface strikingly smooth, canal not visible; fiber bundles usually accompanied by spirals..........................(*Phormium Tenax*).

3. Fibers distinctly pointed at ends, with irregular diameters, thick cell wall, and distinct narrow lumen..........................4.

4. Fiber bundles accompanied by spirals and epidermal cells..........................*Agave* (Sisal, Henequen, etc.).

4. Fiber bundles free from spirals. Characteristic surface markings on fiber..........*Jute.*

2. Fibers red, purple or blue..........................5.

5. Fibers ribbon-like, flat, twisted, with broad lumen..........................*Cotton.*

5. Fibers not twisted; lumen narrow; bumps, swellings, cross striations on fiber surface. Red fibers frequently accompanied by yellow epidermal cells (shive)............6.

6. Stain with Herzog's cyanin (or with Aniline sulfate). Fibers stained.............7.

7. Stain with Herzberg's solution: Yellow epidermal cells with prominent hook hairs near stomatal openings.......*Sunn Hemp.*

7. Yellow epidermal cells devoid of hairs...*True Hemp.*

6. Stained with Herzog's cyanin. Fibers colorless..........................*Flax.*

C. Vegetable Fibers from Fabrics

(Or used in Battings, Cushion Filling, etc.).

1. Fibers silky in appearance, with shiny surface...........2.

2. Fibers short, very fine, downy; examined under microscope showing broad lumen, air filled; very thin cell wall..........................*Kapok.*

2. Fibers of indeterminate length; threadlike............3.

3. Dip for 3 minutes in Hahn's stain, wash in cold water. Fibers pink..........................4.

4. Fibers deep pink..........................***Nitrocellulose Silk.***[1]

4. Fibers pale pink..........................***Viscose Silk.***[2]

3. Fibers not pink..........................5.

5. Fibers yellow..........................***Acetate Silk.***[3]

5. Fibers blue..........................***Cuprammonium Silk.***

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[1] Confirm by test with diphenylamine—sulfuric acid for blue color.

[2] Confirm by microscopical examination for striated surfaces.

[3] Confirm by dissolving in acetone.

1. Fibers not silky..6.

6. Stain with Herzberg's solution, examine microscopically. Fibers yellow................Jute.

6. Fibers red or purple..........................7.

7. Fibers with narrow lumen, swollen nodes, distinct cross markings................8.

8. Moisten tip of single fiber between thumb and finger:
Fiber curls clockwise..................*Linen.*

8. Fiber curls counter-clockwise...........*Hemp.*

7. Fibers with broad lumen..................9.

9. Fibers broad, flat, with unusually wide diameter; joints and transverse fissures prominent..............*Ramie.*

9. Fibers not broad and flat; diameters more or less uniform............*Cotton* 10.

10. Fibers ribbon-like, twisted.......*Raw Cotton.*

10. Fibers swollen, round, with partially destroyed lumen......*Mercerized Cotton.*

METHODS FOR THE QUANTITATIVE ANALYSIS OF TEXTILES

Scope

1. These methods provide for the quantitative determination of the water, total non-fibrous materials, cellulose acetate rayon, silk, regenerated cellulose rayon, cotton, and wool present in textiles composed of two or more of these materials. Any section of the methods which is not applicable in a particular analysis may be omitted. It is assumed that the analyst knows from qualitative tests what materials are present. All results shall be based upon the weight of the dried material.

Water or Regain

2. (*a*) Unless otherwise specified, samples to be analyzed for water shall be conditioned by exposure to an atmosphere having a relative humidity of 63 to 67 per cent and a temperature of 70 to 80 F. (approximately 21 to 26 C.) until equilibrium is established. The material shall be considered to be in equilibrium when it shows no progressive change in weight.

(*b*) The special equipment for drying specimens to constant weight which is generally available in textile laboratories may be used. The procedure outlined in Paragraphs (*c*) to (*f*) is provided for laboratories not so equipped and shall be used in the settlement of disputes unless some other method is agreed upon by those concerned.

(*c*) A glass weighing bottle of approximately 100-ml. capacity fitted with a ground-glass cover shall be dried at 221 to 230 F. (105 to 110 C.) to constant weight. A satisfactory procedure is to place the bottle and cover separately in the oven. After drying for 1 hr. they shall be transferred to a desiccator and allowed to cool to room temperature. The cover shall then be placed on the bottle which shall then be weighed. The heating, cooling and weighing shall be repeated until the weight is constant to within ± 0.003 g. This is the "weight of weighing bottle." The weighing bottle shall be kept in a desiccator when not in use.

(*d*) A specimen of approximately 5 g. of the material to be tested shall be placed in the weighing bottle which shall then be covered and weighed. By subtracting the "weight of weighing bottle" (Paragraph (*c*)) from this weight, the weight of specimen, A, is obtained.

(*e*) The specimen shall be removed from the weighing bottle, placed on a watch glass in the oven (temperature 221 to 230 F. (105 to 110 C.) as before), and dried for 1.5 hr., then quickly transferred to the weighing bottle, which shall be placed uncovered in a desiccator. When the specimen and bottle have cooled to room temperature, the cover shall be replaced on the bottle which shall then be weighed. The specimen shall be returned to the oven and the drying, cooling and weighing shall be repeated until the weight is constant to within ±0.003 g. By subtracting the "weight of weighing bottle" (Paragraph (*c*)) from this weight, the weight of dry specimen, B, is obtained.

(*f*) *Calculation.*—The water content shall be calculated from the following formula:

$$\text{Water content of specimen (dry basis) or regain, per cent} = \frac{A - B}{B} \times 100$$

where A = the weight of specimen; and
B = the weight of dry specimen.

Total Sizing, Finishing and Other Non-Fibrous Materials

3. (*a*) The purpose of this procedure is to remove all non-fibrous natural constituents of the fiber and substances added by the manufacturer. Starch, China clay, soaps, some waxes, some non-drying oils and the usual natural constituents are in this category and are removed by the procedure given. However, general directions for the removal of all possible substances which may be present cannot be given. The delustered rayons and some of the newer finishes present special problems. The analyst will have to meet special cases as they arise. When it is necessary to modify the procedure in order to completely remove non-fibrous constituents, the analyst

shall make sure that purified samples of the fibers under consideration do not lose weight when subjected to the same treatment and the samples shall then be analyzed according to Paragraphs (*b*) to (*d*).

(*b*) A specimen of approximately 5 g. shall be taken for test. Particular care shall be taken to prevent the loss of fibers in the treatments. The specimen shall be dried at 221 to 230 F. (105 to 110 C.) to constant weight (Section 2 (*e*)). This gives the weight of dry specimen, *B*.

(*c*) The specimen shall then be extracted for 2 hr. with carbon tetrachloride in a Soxhlet or similar extractor. The specimen shall be allowed to dry in the air. It shall then be washed while squeezing by alternate immersion in hot distilled water.

(*d*) The specimen shall then be immersed in a suitable aqueous solution of a starch hydrolyzing enzyme at 122 F. (50 C.). It shall be squeezed while immersed, then removed and squeezed again. This procedure shall be repeated with the same solution for a total of three times. The enzyme solution shall then be heated to 158 F. (70 C.), and the specimen immersed in it for a period of 15 minutes, the temperature of the solution being maintained at 158 F. ± 2 F. (70 C. ± 1.1 C.). The specimen shall then be rinsed twelve times in fresh portions of hot distilled water, squeezing after each rinse, and then dried at 221 to 230 F. (105 to 110 C.) to constant weight (Section 2 (*e*)). This gives the weight of dry fiber, *C*.

(*e*) *Calculation.*—The total amount of non-fibrous constituents present shall be calculated from the following formula:

$$\text{Total sizing, finishing and other non-fibrous materials (dry basis), per cent} = \frac{B - C}{B} \times 100$$

where B = the weight of dry specimen (Paragraph (*b*)); and
C = the weight of dry fiber (Paragraph (*d*)).

Cellulose Acetate Rayon
(Acetone Soluble Types Only)

4. (*a*) The specimen after being tested in accordance with Section 3 shall be agitated vigorously for 15 minutes in about 50 times its weight of acetone at room temperature.[1] The residue shall be rinsed while squeezing by alternate immersion in acetone, two fresh portions of acetone being used. The residue shall be allowed to dry and them immersed in water at a temperature of about 158 F. (70 C.). The excess water shall be removed by squeezing and the residue dried to constant weight as described in Section 2 (*e*). This weight is called *D*.

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[1] A Launder-ometer can be used to obtain satisfactory agitation.

(*b*) *Calculation.*—The cellulose acetate rayon content shall be calculated from the following formula:

$$\text{Cellulose acetate rayon (dry basis), per cent} = \frac{C - D}{B} \times 100$$

where B = the weight of dry specimen (Section 3 (*b*));
C = the weight of dry fiber (Section 3 (*d*)); and
D = the weight of dry specimen after cellulose acetate rayon test.

Silk

5. (*a*) The residue from the test for cellulose acetate rayon (Section 4) shall be agitated vigorously for 15 minutes in about 100 times its weight of a clear aqueous solution of calcium thiocyanate (sp. gr. 1.20) at a temperature of 158 F. (approximately 70 C.). The residue shall be rinsed by alternate immersion in fresh calcium thiocyanate solution at the same temperature and concentration and squeezed against the side of the container. The residue shall be rinsed and squeezed in this manner for a total of two times. It shall then be rinsed thoroughly in hot water and dried to constant weight, weight E.

(*b*) *Calculation.*—The silk content shall be calculated from the following formula:

$$\text{Silk (dry basis), per cent} = \frac{D - E}{B} \times 100$$

where B = the weight of dry specimen (Section 3 (*b*));
D = the weight of dry specimen (Section 4 (*a*)); and
E = the weight of dry specimen after silk test.

Regenerated Cellulose Rayon

6. (*a*) The residue from the test for silk (Section 5) shall be treated in accordance with the procedure in Section 5 but using a solution of calcium thiocyanate (sp. gr. of 1.36) at a temperature of 158 F. (70 C.). The weight of the dried residue from this treatment is F.

(*b*) *Calculation.*—The regenerated cellulose rayon content shall be calculated from the following formula:

$$\text{Regenerated cellulose rayon (dry basis), per cent} = \frac{E - F}{B} \times 100$$

where B = the weight of dry specimen (Section 3 (*b*));
E = the weight of dry specimen after the silk test (Section 5 (*a*));
F = the weight of the dried residue.

Cotton

7. (*a*) The residue from the test for regenerated cellulose rayon (Section 6) which contains cotton and wool shall be immersed for 10 minutes in a boiling solution of aluminum chloride containing 5 g. of $AlCl_3$ (or 9 g. of the hydrated salt $AlCl_3 \cdot 6H_2O$) per 100 ml. of water. It shall be removed from the solution and after allowing the excess liquid to drain off (the specimen shall not be squeezed), it shall be heated for 2 hr. (or until the cotton has become brown in color and brittle) in an oven at 221 to 230 F. (approximately 105 to 110 C.). The specimen shall then be held over a piece of glazed paper and rubbed between the fingers in order to pulverize the carbonized cellulose and separate it from the wool. By suitable manipulation all of the wool shall be obtained in a mat and most of the cellulose left on the paper in the form of a powder. The separation is facilitated by the use of a wire screen of about 40-mesh between the hands and the glazed paper. The wool shall be shaken with about 100 ml. of a 10 per cent solution of HCl in an Erlenmeyer flask. After standing for about 5 minutes the contents of the flask shall be poured on a 100-mesh wire screen. The residue on the screen shall be washed with a stream of water until all cellulosic material has been carried through the screen. The wool shall then be rinsed with a 2 per cent solution of sodium carbonate to neutralize any acid, and finally rinsed thoroughly with water and dried at 221 to 230 F. (105 to 110 C.) to constant weight, weight G.

(*b*) *Calculation.*—The cotton content shall be calculated from the following formula:

$$\text{Cotton (dry basis), per cent} = \frac{F - G}{B} \times 100$$

where B = the weight of dry specimen (Section 3 (*b*));
F = the weight of the dried residue (Section 6 (*a*)); and
G = the weight of the dry specimen after the cotton test.

Wool

8. The wool content of the specimen shall be calculated from the following formula:

$$\text{Wool (dry basis), per cent} = \frac{G}{B} \times 100$$

where B = the weight of dry specimen (Section 3 (*b*)); and
G = the weight of the dry specimen after the cotton test.

TENTATIVE DEFINITIONS AND TERMS RELATING TO TEXTILE MATERIALS[1]

A.S.T.M. Designation: D 123 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED AS TENTATIVE, 1921; ADOPTED IN AMENDED FORM, 1927; REVISED, 1930; REISSUED AS TENTATIVE, 1933.

Abacá.—See Fibers, Vegetable.

African Sisal.—Under Fibers, Vegetable, see Sisal.

Airplane Fabric (Cotton).—A plain-weave fabric well woven, practically without imperfections, of mercerized two-ply yarns, width 36 to 56 in., maximum weight 4.5 oz. per sq. yd., and threads per inch warp and filling 80 to 84.

Ambari.—Under Fibers, Vegetable, see Kenâf.

Asbestos Roving.—Asbestos roving is composed of a mixture of chrysotile asbestos and cotton or other vegetable fiber.

Reinforced Asbestos Roving.—Reinforced asbestos roving is composed of a core of cotton yarn covered with a mixture of chrysotile asbestos and vegetable fiber.

Asbestos Yarn.—Yarn consisting of: (1) asbestos fiber; (2) asbestos and vegetable fibers; or (3) asbestos, vegetable fibers and wire.

Plain Asbestos Yarn.—Yarn consisting of: (1) asbestos fiber, or (2) asbestos and vegetable fibers.

Metallic Asbestos Yarn.—Yarn consisting of plain asbestos yarn twisted with brass, copper or other fine wire.

Bad Casts (Raw Silk).—Abruptly thickened places on the threads due to the cocoon filament not being properly attached to the thread, or made by adding more than one cocoon filament at a time.

Bagging.—A very heavy loosely woven fabric used for bale tares, etc., woven from heavy tight-twisted roving, consisting largely of reworked and waste fibers. Also known as "gunny."

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[1] Criticisms of these Tentative Definitions are solicited and should be directed to Mr. W. H. Whitcomb, Secretary of Committee D-13 on Textile Materials, Interlaken Mills, West Warwick, R. I.

These tentative definitions comprise a revision and combination of the former Standard Definitions of Terms Relating to Textile Materials (A.S.T.M. Designation: D 123 - 30) and Tentative Definitions of Terms Relating to Textile Materials (A.S.T.M. Designation: D 123 - 30 T), which definitions were accordingly discontinued in 1933.

Bahama Sisal.—Under Fibers, Vegetable, see Sisal.

Benares Sunn.—Under Fibers, Vegetable, see Sunn.

Bimlipatam Jute.—Under Fibers, Vegetable, see Kenâf.

Binder Twine.—A somewhat stiff, single strand yarn, 3 to 4 mm. in diameter, made of hard fibers (henequen, sisal, abacá, or phormium), used chiefly for binding bundles of grain, etc.

Boiled-Off Silk.—Silk with the gum (sericin) removed.

Bombay Aloe.—Under Fibers, Vegetable, see Cantara and Piteira.

Book-Fold.—The fabric is doubled selvage to selvage, then folded back and forth upon itself in predetermined lengths. When the piece is completed, the fold-edges on each side are folded to the center and the piece is folded once more upon itself so that the fold-edges are inside, forming a compact package as long as one-half the width of the goods.

Broken Pick.—A streak across the width of the fabric caused by a completely or partially missing pick.

Brown Hemp.—Under Fibers, Vegetable, see Sunn.

Burlap (Jute).—A coarse, heavy, plain-weave fabric of coarse single yarn.

Cable Twist.—A twine, cord, or rope construction in which each successive twist is in the opposite direction to the preceding twist.

Cantala.—See Fibers, Vegetable

Cellulose-Acetate Rayon.—See Fibers, Artificial.

China Grass.—See Fibers, Vegetable.

China Hemp.—Under Fibers, Vegetable, see Hemp.

Chingma.—See Fibers, Vegetable.

Cockled or Cockling.—A curliness or crimpiness appearing in fabrics when different sizes of yarn or varying tensions on the yarns are accidentally introduced.

Coir.—See Fibers, Vegetable.

Cordage.—A term used in a collective sense to include all sizes and varieties of twines, cords, ropes and cables of textile materials.

Cordage Fibers.—See Fibers, Cordage.

Corkscrews (Raw Silk).—A place in the thread in which one or more cocoon filaments are longer than the remainder and give the appearance of a spiral form.

Heavy Corkscrews (Raw Silk).—Corkscrews which are more than twice the diameter of the thread.

Corkscrew Twist.—A place in the yarn or cord where an uneven twist gives a corkscrew-like appearance.

Cotton.—See Fibers, Vegetable.

Crimp.—The difference in distance between two points on a yarn as it lies in a fabric and the same two points when the yarn has been removed from the fabric and straightened, expressed as a percentage of the distance between the two points as the yarn lies in the fabric.

Cuprammonium Rayon.—See Fibers, Artificial.

Cut (Asbestos).—A term indicating the size of asbestos yarn. The word "cut" preceded by a number indicates, in multiples of 100 yd., the yardage per pound of single-ply yarn. For example, "5 cut" indicates that a pound of single-ply yarn so designated measures approximately 500 yd.; "10 cut" indicates a yarn that measures approximately 1000 yd. per lb.

(Woolen).—See Yarn Number (Woolen—Cut).

Da or Dha.—Under Fibers, Vegetable, see Kenâf.

Daisee Jute.—Under Fibers, Vegetable, see Jute.

Defective Splice.—A splice having irregular final twist, untrimmed ends, or excessive thickness or thinness.

Denier.—A unit of weight (0.05 g.) used to express the size of silk and rayon. The weight in units of 0.05 g. of a 450-m. skein at standard conditions is the denier of silk and rayon (exclusive of spun silk and staple rayon) yarn. It is also equal numerically to the weight in grams of a 9000-m. skein at standard conditions.

Dungaree (Cotton).—A heavy cloth woven in the 2/1 twill weave from dyed warp and filling yarns, in narrow widths, usually 28 in.; approximate number of threads per inch, warp 68 and filling 52; yarn number both warp and filling 20's.

End.—An individual warp yarn.

Felt Jackets.—See Jackets.

Fiber.—A slender, elongated filament, such as rayon, silk, or wool; or a single elongated cell, like cotton or kapok; or a slender strand composed of aggregations of elongated cells like flax, jute and sisal.

Fibers, Artificial:

Cellulose-Acetate Rayon.—Filaments composed of an acetic ester of cellulose which has been coagulated or solidified from its solution.

Cuprammonium Rayon.—Filaments composed of a regenerated cellulose which has been coagulated or solidified from a solution of cellulose in ammoniacal copper oxide.

Nitrocellulose Rayon (Chardonnet).—Filaments composed of a regenerated or denitrated cellulose which has been coagulated or solidified from a solution of nitrated cellulose.

Viscose Rayon.—Filaments composed of a regenerated cellulose which has been coagulated or solidified from a solution of cellulose xanthate.

Fibers, Cordage.—Coarse hard fibers, such as abacá, sisal, henequen, cantala, phormium, palma and piteira (see Fibers, Vegetable), used in the manufacture of ropes and coarse twines. Generally too coarse and stiff to be woven into fabrics.

Fibers, Hard or Leaf.—Rather stiff elongated strands from leaves like sisal, henequen, and piteira (see Fibers, Vegetable), or leaf stems like abacá, used chiefly in coarse twines, ropes and heavy cordage.

Fibers, Soft or Bast.—Flexible elongated strands from the inner bark of plants like flax, hemp, jute and ramie, used in twines, nets and woven fabrics.

Fibers, Textile.—Slender filaments or strands that cling together, enabling them to be spun into yarns of appreciable strength and sufficiently pliable to be woven or knitted into fabrics. Essential requisites are tensile strength, length of at least 5 mm. and more than 100 times the diameter, pliability and cohesiveness; desirable, but not essential, properties are elasticity, fineness, uniformity, durability and luster. Textile fibers include cotton, flax, jute, and many other fibers of vegetable origin; silk, wool and various hairs of animal origin; rayon and allied synthetic or artificial fibers; and asbestos of mineral origin.

Fibers, Vegetable:

Abacá (a-ba-ká).—A hard fiber, rather coarse, firm texture, cream-white to brown in color, 150 to 350 cm. long, strong and durable from the leaf stems forming the trunk of the abacá plant, *Musa textilis*, cultivated in the Philippine Islands, Sumatra, Java and Borneo; used in ropes and coarse twines and cordage, especially marine cordage, oil-well cables, and binder twine. Called "Manila hemp" in the market, but quite unlike true hemp, also called "Cebu hemp" and "Davao hemp."

Cantala.—A hard fiber, finer, softer and weaker than sisal, yellow-white to brownish white, 75 to 150 cm. long, from leaves of the cantala plant, *Agave cantala*, cultivated in the Philippine Islands, Java, Sumatra and India; used in coarse twines including binder twine. Called "Manila maguey" and "Cebu maguey" in market quotations for water-retted, hand-cleaned cantala of the Philippine Islands.

Fibers, Vegetable (Continued):

China Grass.—Ramie fiber separated from the stalk and the thin outer bark, but not degummed; the form in which it is usually exported from China.

Chingma (Ching′-mah).—A rather coarse soft fiber, usually flaggy and fuzzy, straw-white, from the inner bark of the chingma plant, *Abutilon theophrasti,* cultivated in northern China and Japan. Called "China jute" and "Tientsin jute," but it is not a true jute.

Coir.—A hard fiber, usually brown, 10 to 25 cm. long, from the outer husk of the cocoanut, *Cocos nucifera,* produced chiefly in Ceylon and southern India; used in door mats and as a stuffing fiber in upholstery.

Cotton.—Fine, one-celled, twisted fibers, white or in some types tawny, brown or green, 20 to 50 mm. long, growing on the seeds of several different species of the genus *Gossypium*; used more than all other vegetable fibers, and for a wider range of purposes including yarns, twines, woven and knit goods, upholstery stuffing and packing.

American short-staple upland cotton.—Fiber 20 to 27 mm. long, from *Gossypium hirsutum,* cultivated in the southern part of the United States and introduced into nearly all cotton-growing countries.

American long-staple upland cotton.—28 to 40 mm. long, from selected varieties of *Gossypium hirsutum,* cultivated largely in the Yazoo-Mississippi delta. Also called "delta cotton."

Arizona Egyptian cotton.—Fiber 35 to 45 mm. long, from modified forms of *Gossypium barbadense,* cultivated in Arizona and southern California, includes "Pima cotton."

Egyptian cotton.—Fiber 30 to 40 mm. long, white or in some varieties light brown, from modified forms of *Gossypium barbadense,* cultivated chiefly in lower Egypt, includes "Sakellarides," "Zagora," etc.

India cotton.—Short staple, 18 to 25 mm. long, from *Gossypium neglectum,* cultivated in India.

Levant cotton.—Short staple, 18 to 25 mm. long, from *Gossypium herbaceum,* cultivated in Asia Minor and countries bordering the Mediterranean Sea.

Fibers, Vegetable (Continued):

Rough Peruvian cotton.—A rather harsh, wiry cotton, from *Gossypium peruvianum*, cultivated in Peru, used chiefly for mixing with wool.

Sea island cotton.—Fine fiber, 30 to 50 mm. long, from *Gossypium barbadense*, cultivated chiefly in the West Indies, used in the finest cotton yarns.

Flax.—A soft, fine fiber, dark gray, bluish green, brown or cream white, 40 to 100 cm. long, from the inner bark of the fiber flax plant, *Linum usitatissimum*, cultivated chiefly in northern Europe; used in linen thread, shoe thread, seine twine, sacking twine, laces, table linen, handkerchiefs, towels and in all true linens.

Courtrai flax.—Flax fiber of superior quality, very carefully prepared from straw retted in the River Lys, or most of it in recent years tank-retted in the vicinity of Courtrai, Belgium.

Dew-retted flax (Slanetz of Russia).—Flax fiber prepared by spreading the plants on the ground and exposing to the weather for retting.

Flax tow.—Short or tangled fiber beaten out in scutching—often called scutching tow; or combed out in hackling and called machine tow; used in flax yarns and twines. (This flax tow is distinctly different from upholstery flax tow.)

Flemish flax.—Flax produced in Flanders (northeastern France and Belgium).

Hackled flax (also called "dressed flax" or "dressed line").—Flax fiber, which after being scutched, has been cleaned further by combing over hackles.

Irish flax.—Flax fiber produced in northern Ireland, mostly retted in bogs, yielding a very strong fiber.

Risten (*R* in market quotations).—The standard grade of flax on which other grades of the Baltic countries are based.

Water-retted flax (Motchenetz of Russia).—Flax fiber, light cream-white to gray in color, prepared by retting the plants in water.

Fibers, Vegetable (Continued):

Hemp.—A soft fiber, dark steel gray to cream-white, usually in narrow flat ribbons, 100 to 250 cm. long, from the inner bark of the hemp plant, *Cannabis sativa*, cultivated in Italy, Soviet Republic, Yugoslavia, Hungary, China, Japan, Chile, Wisconsin, Illinois and Kentucky; used in America in commercial twines, marlines, halyards and tarred rigging.

Hemp line.—Hemp fiber, scutched and prepared so that the fibers lie straight and parallel.

Hemp tow.—Short or tangled hemp fiber, beaten out in scutching the long fiber, or hemp fiber produced from short or tangled stalks.

Italian hemp.—Hemp fiber produced in Italy, mostly water-retted and well prepared and graded.

Kentucky rough prime.—The best quality of Kentucky dew-retted hemp, broken on hand brakes, but not hackled.

Kentucky single-dressed.—Kentucky hemp further prepared by drawing it over a coarse hackle.

Russian hemp.—Hemp fiber chiefly dew-retted and prepared by hand in the Soviet Republic.

Wisconsin hemp.—Hemp fiber produced in Wisconsin by dew-retting and breaking and scutching by machinery.

Henequen (hen-e-ken′).—A hard fiber, rather coarse, of firm texture, light yellow or sometimes reddish yellow, cylindrical, 75 to 150 cm. long, from the leaves of the henequen plant, *Agave fourcroydos*, cultivated in the Yucatan peninsula, and in Tamaulipas in Mexico and in Cuba; used chiefly in binder twine and in other coarse twines and small ropes.

Istle (eest′-ley).—Hard fibers, light yellow, 20 to 50 cm. long, cylindrical and stiff, from the leaves of two closely related species of *Agave*, growing without cultivation in Mexico, used chiefly in brushes, and to a less extent in twines; used in Mexico for handmade twines and coarse sacks. Also called "Tampico" and "Mexican Fiber."

Jute.—Soft fibers, light yellow to nearly white or bright copper to deep slate, changing in age to dingy brown or gray, 100 to 500 cm. long, averaging about 240 cm. exclusive of butts,

Fibers, Vegetable (Continued):

Jute (Continued):

from the inner bark of the round-pod jute, *Corchorus capsularis*, and the long-pod jute, *Corchorus olitorius*, cultivated in India, chiefly in Bengal, and to a very limited extent elsewhere in southern Asia and in tropical Africa; used in twines, gunnies, burlaps, hessians, carpet yarns, sacks for sugar, coffee, grain, feed, fertilizer and wool, and backing for linoleum and oilcloths.

Jute butts.—The flaggy lower ends of jute fiber, 10 to 25 cm. long, cut off in preparing jute for market, used in twines and coarse bagging, especially in covering for bales of cotton.

Daisee jute (also spelled *desi* and *deshi*, meaning "local").—Fiber of long-pod jute, *Corchorus olitorius*, grown in the brackish soils in the region of Calcutta, generally ranging from copper brown to slate gray.

Tossa jute.—Fiber of long-pod jute, *Corchorus olitorius*, grown on uplands in eastern India; pearl gray to deep slate color or copper brown.

Kapok.—Stuffing fiber or down, composed of single cells, 20 to 30 mm. long, white gray or tawny in color, produced in the seed pods of the kapok tree, *Ceiba pentandra*, and closely allied species of the bombax family, resistant to the absorption of moisture, resilient and buoyant; used as stuffing in pillows, mattresses and life preservers and for temperature and sound insulation.

Kenáf.—A soft jute-like fiber, light yellow to gray, flaggy at base, 150 to 250 cm. long, from the inner bark of the kenáf plant, *Hibiscus cannabinus*, cultivated most extensively in Persia and Trans-Caspian Russia. Called "Da" in French West Africa, "Gombo" in Portuguese Africa, "Ambari" and "Deccan Hemp" in India, "Bimlipatam" in Madras Presidency; used in twines and for purposes similar to jute.

Mescal Maguey.—A hard fiber, light straw-yellow, slightly finer and softer than sisal, 80 to 150 cm. long, from leaves of the mescal maguey plant, *Agave pseudotequilana*, cultivated in western Mexico; used in twines and cordage.

Fibers, Vegetable (Continued).

Palma.—A hard fiber nearly white or light brownish yellow, often with some coarser dark brown curved ends, 25 to 50 cm. long, from the leaves of a tree yucca, *Samuela carnerosana*, growing on high mountains in northern Mexico; used for twines, especially "paper twines." Also called "palma istle," but quite unlike istle fibers.

Phormium (for′-mi-um).—A hard fiber, reddish yellow or nearly white, finer and softer than abacá, 150 to 300 cm. long, from the leaves of the harakeke lily, *Phormium tenax*, growing wild and cultivated in New Zealand, and cultivated in St. Helena; used chiefly in hard fiber twines, including binder twine. Called "New Zealand hemp" and "New Zealand flax" but the fiber is unlike hemp or flax.

Piteira (pe-ter′-a).—A hard fiber, nearly white, and finer and softer than other hard fibers as it is prepared in Mauritius, 150 to 250 cm. long, from the leaves of the giant cabuya, *Furcraea gigantea*, native in eastern Brazil and cultivated in Mauritius, India and Natal; used chiefly for mixing with other fibers to improve the color of ropes. Called "Mauritius hemp," but it is not a true hemp and is produced in other countries besides Mauritius.

Ramie.—A soft fiber, parchment-like, light yellow or greenish and stiff in the form called "China grass," white, soft and slightly coarser than flax when degummed and bleached, very strong and durable, from the inner bark of the ramei plant, *Boehmeria nivea*, cultivated in China and Japan; used in China for dress goods and "grass cloth," in Japan for seine twine and mosquito nets and in Germany for shoe thread, trimmings, tapestries, and various woven fabrics. Also called "rhea."

Sisal.—A hard fiber, of firm texture, light yellow or nearly white sometimes slightly green, very strong and durable, 100 to 180 cm. long, from the leaves of the sisal plant, *Agave sisalana*, native in Yucatan, cultivated in East Africa, Java, Sumatra, Haiti and the Bahamas; used in hard fiber twines including binder twine and also in coarse cordage.

Bahama Sisal.—Retted in sea water and cleaned by hand; is finer, softer, weaker and lacking in luster.

Fibers, Vegetable (Continued):

Sunn.—A soft fiber, gray or brown with a wide range of color and quality due to differences in preparation, 50 to 150 cm. long, from the inner bark of the sunn plant, *Crotalaria juncea*, cultivated in India; used in twines. Also called "Sunn hemp," "India hemp," "Bombay hemp," "Brown hemp," and various sorts by the names "Benares," "Itarsi," "Jubbulpore," "Madras" and "Sewnee."

Filament.—A fine fiber or fibril.

Flax.—See Fibers, Vegetable.

Float (Defect).—A place in the fabric where warp or filling threads extend unbound over threads with which they should be interlaced.

Gage.—A measure of the fineness of knit fabric as determined by the closeness of the wales, that is, the longitudinal rows of loops. It is expressed by the number of wales or needles in one and one half inches.

NOTE.—The word "gage" is also used as an expression of thickness.

Gombo Hemp.—Under Fibers, Vegetable, see Kenâf.

Grenadine Yarn (Silk).—A yarn composed of more than one strand, each individual strand of which has been doubled with a reverse twist, each twist having a minimum of approximately the following number of turns per inch depending on the number of strands used:

STRANDS	MINIMUM NUMBER OF TURNS
2 ($\frac{13}{15}$ denier or equivalent)	32
3	30
4	28

NOTE.—When more than 4 strands are used, the minimum number of turns are decreased in accordance with the above proportion.

Hairiness (Raw Silk).—The condition of the thread when there are numerous loose ends of cocoon filaments projecting from the thread.

Hawser Twist (Cotton).—A twine, cord or rope construction in which the first and second twists are in the same direction and the third twist in the opposite direction.

Heavy Corkscrews.—See Corkscrews.

Heavy Goods.—Name applied in Calcutta quotations to material called "sacking" in the United States.

Hemp.—See Fibers, Vegetable.

Henequen.—See Fibers, Vegetable.

Hessians.—Name applied in United Kingdom, India, and on the Continent to material called "burlap" in the United States.

Holland Finish (Cotton).—A glazed or unglazed finish, consisting of oil and a filling material, applied to cotton fabrics to make them opaque or semi-opaque; resembles a beetled linen fabric formerly known as "Holland."

Indian Hemp.—Under Fibers, Vegetable, see Sunn.

Istle.—See Fibers, Vegetable.

Italian Hemp.—Under Fibers, Vegetable, see Hemp.

Jackets (woven or felted).—A textile product, woven or pressed into tubular or sleeve form, ready for covering and shrinking on a machine roll.

Jubbulpore Hemp.—Under Fibers, Vegetable, see Sunn.

Jute.—See Fibers, Vegetable.

Jute Butts.—See Fibers, Vegetable.

Kapok.—See Fibers, Vegetable.

Kenáf.—See Fibers, Vegetable.

Kink (fabric).—A place in the fabric where a slack strand has twisted on itself, forming a loop in the yarn or cord.

Knot.—A joining by tying of threads together.

Long Knots (Raw Silk).—Knots which have loose ends from 3 to 25 mm. ($\frac{1}{8}$ to 1 in.) in length.

Very Long Knots (Raw Silk).—Knots which have loose ends exceeding 25 mm. (1 in.) in length.

Laid Fabric (Cotton).—A fabric made without filling yarn, the parallel warp yarns being held together by means of rubber latex or other binding material.

Lea (Cotton).—A 120-yd. skein of yarn containing 80 turns, that is, each $1\frac{1}{2}$ yd. in length.

(Linen).—See Yarn Number (Linen).

Loop-Knot.—A snarl or curl produced by a filling yarn coiling upon itself.

Loops (Raw Silk).—Small open places in the thread due to the excessive length of one or more cocoon filaments.

Long Loops.—Loops which exceed 1 cm. ($\frac{1}{2}$ in.) in length.

Long Knot.—See Knot.

Maguey.—Under Fibers, Vegetable, see Cantala and Mescal Maguey.

Manila Hemp.—Under Fibers, Vegetable, see Abacá.

Mauritius Hemp.—Under Fibers, Vegetable, see Piteira.

Mescal Maguey.—See Fibers, Vegetable.

Metallic Asbestos Yarn.—See Asbestos Yarn.

Mexican Fiber.—Under Fibers, Vegetable, see Istle.

Mexican Sisal.—Under Fibers, Vegetable, see Henequen.

Mispick.—A pick not properly interlaced.

Moisture Content (Moisture, percentage of moisture).—The moisture present in a textile material expressed as a percentage of the original weight as determined by definite prescribed methods.

Moisture-Free Weight.—The weight of a textile material determined after drying to constant weight by definite prescribed methods.

Moisture Regain.—The moisture present in a textile material expressed as a percentage of the moisture-free weight, as determined by definite prescribed methods.

Natal Hemp.—Under Fibers, Vegetable, see Piteira.

Neatness (Raw Silk).—An expression of the degree of freedom of the raw silk thread from loops, nibs, and hairiness as defined.

New Zealand Flax.—Under Fibers, Vegetable, see Phormium.

Nibs (Raw Silk).—Small thickened places less than 3 mm. ($\frac{1}{8}$ in.) in length.

Nitrocellulose Rayon.—See Fibers, Artificial.

Number of Yarn.—See Yarn Number.

Off-Square.—The difference between the percentage of warp crimp and the percentage of filling crimp.

Organzine Yarn.—Two or more raw silk strands twisted in the singles, doubled and twisted in the reverse direction in the ply. Turns per inch in the singles and ply usually within the limits of 10 to 20 turns; generally used as warp.

Palma.—See Fibers, Vegetable.

Philippine Maguey.—Under Fibers, Vegetable, see Cantala.

Phormium.—See Fibers, Vegetable.

Pick.—An individual filling yarn.

Piteira.—See Fibers, Vegetable.

Plain Weave.—A fabric pattern in which each yarn of the filling passes alternately over and under a yarn of warp and each yarn of the warp passes alternately over and under a yarn of the filling.

Ramie.—See Fibers, Vegetable.

Raw Silk.—Silk as it has been reeled from the cocoon.

Rayon.—A generic term for filaments made from various solutions of modified cellulose by pressing or drawing the cellulose solution through an orifice, and solidifying it in the form of a filament.

NOTE.—Rayon as commercially manufactured is produced by four different processes. The resulting rayons from each process while similar in appearance differ amongst themselves and with each other to a more or less degree according to the differences in their physical and chemical properties. The different type rayons are known as follows:

(*a*) Nitrocellulose Rayon (Chardonnet)
(*b*) Viscose Rayon
(*c*) Cuprammonium Rayon
(*d*) Cellulose-Acetate Rayon

Reed Marks.—Marks or lines warpwise of the cloth, usually caused by too many or too few warp yarns being drawn into a dent, a faulty setting of the loom, or imperfections in the reed.

Regain.—See Moisture Regain.

Reinforced Asbestos Roving.—See Asbestos Roving.

Run (Woolen).—See Yarn Number (Woolen Run).

Russian Hemp.—Under Fibers, Vegetable, see Hemp.

Sewed Yarn.—A yarn in the fabric interwoven by hand.

Shoe-Fold.—The fabric is folded from both ends into twelve or sixteen folds to the piece, the length of the fold depending upon the length of the piece.

Sisal.—See Fibers, Vegetable.

Size.—See Yarn Number.

Slub.—See Slug (General).

Slug (Raw Silk).—A thickened place several times the diameter of the thread, 3 mm. ($\frac{1}{8}$ in.) or over in length.

Long or Large Slug (Raw Silk).—A slug which exceeds 1 cm. ($\frac{1}{2}$ in.) in length or which is very much larger in diameter than the thread.

(General).—An abruptly thickened place in the yarn or a bunch of lint entangled in the yarn, cord, or fabric.

Smash.—A place in the fabric where a number of warp yarns or cords have been broken, usually due to the shuttle getting caught in the shed during weaving, or to faulty harness motion.

Spun Silk.—Silk yarn consisting of short filaments obtained from silk wastes spun in a similar manner to worsted yarn.

Standard Atmosphere (Textiles).—Air maintained at a relative humidity of 65 per cent at a temperature of 70 F.

Standard Moisture Regain.—An arbitrary figure formally adopted for the regain of any specific textile material to be used in calculating the standard weights of shipments or deliveries of textiles.

Standard Weight.—The moisture-free weight of a textile material plus the weight corresponding to its standard moisture regain.

Sunn.—See Fibers, Vegetable.

Tampico Fiber.—Under Fibers, Vegetable, see Istle.

Thick and Thin Places (Major Defects).—Places in the fabric where for 1 in. or more the count varies more than a specified percentage from the specified count.

(Minor Defects).—Places in the fabric where for less than 1 in. the count varies more than a specified percentage from the specified count.

Thread (Silk).—The ply of yarns is sometimes referred to as the number of thread, as 2 thread for a 2 ply.

Thrown Silk.—Raw silk that has been twisted, or doubled and twisted.

Tientsin Jute.—Under Fibers, Vegetable, see Chingma.

Tire Builder Fabric.—A fabric consisting of hawser cord yarn in the warp with single yarn filling at intervals to keep the warp threads together.

Tossa Jute.—Under Fibers, Vegetable, see Jute.

Tram Yarn (Silk).—Raw silk threads doubled and twisted with a low number of turns per inch, generally used as filling.

Tula Istle.—Under Fibers, Vegetable, see Istle.

Twill Weave.—A weave which produces pronounced lines running diagonally across the fabric.

Warp Face Twill.—A twill weave in which the warp threads produce the diagonal effect.

Twine (Not Binder Twine).—A cord made up of two or more yarns of medium twist with ply twist in the opposite direction.

Twist, Direction of.—In the case of yarn or cord, the yarn or cord has right-hand or regular twist if when it is held vertically the spirals or twists are seen to incline upward in a right-hand direction and has left-hand or reverse twist when the spirals or twists are seen to incline upward in a left-hand direction.

NOTE.—Attention is called to the fact that this definition of twist is opposite to that used in sewing thread manufacture.

Viscose Rayon.—See Fibers, Artificial.

Webbing, Elastic.—A strong narrow fabric made with rubber threads as part of warp or filling or of both.

Wrong Draw.—A defect in a fabric due to the warp and filling not interlacing in accordance with the prescribed weave or design and caused when one or more warp yarns have been drawn through the wrong harness.

Yarn.—An assemblage of fibers or filaments of animal, mineral, or vegetable origin, alone or in combination, either natural or manufactured, twisted or laid together to form a strand or group of strands for use in weaving, knitting, or forming in any manner into textile materials.

Yarn Number (Asbestos).—See Cut (Asbestos).

(Cotton).—The number of 840-yd. hanks contained in 1 lb. avoirdupois (7000 grains) of the yarn at standard conditions. The number of folded or plied yarns is that of the single yarn from which they are spun.

(Jute).—The weight in pounds of a spyndle of 14,400 yd. of yarn at standard conditions expressed as "pounds per spyndle."

(Linen).—The number of 300-yd. hanks contained in 1 lb. avoir dupois (7000 grains) of the yarn at standard conditions. The number of folded or plied yarns is that of the single yarn from which they are spun. Also known as "lea."

(Raw Silk).—See Denier.

(Rayon).—See Denier.

(Spun Rayon).—The number of 840-yd. hanks contained in 1 lb. avoirdupois (7000 grains) of the yarn at standard conditions. The number of folded or plied yarns is that of the single yarn from which they are spun.

(Spun Silk).—The number of 840-yd. hanks contained in 1 lb. avoirdupois (7000 grains) of the yarn at standard conditions. The number of folded or plied yarns is that of the finished yarn.

(Woolen—Cut).—The number of 300-yd. "cuts" or hanks in 1 lb. avoirdupois (7000 grains) of the yarn at standard conditions.

(Woolen—Run).—The number of 1600-yd. hanks in 1 lb. avoirdupois (7000 grains) of the yarn at standard conditions.

(Worsted).—The number of 560-yd. hanks in 1 lb. avoirdupois (7000 grains) of the yarn at standard conditions. The number of folded or plied yarns is that of the single yarn from which they are spun.

Yarn Size.—See Yarn Number.

TENTATIVE METHODS OF COMPRESSION TESTING OF METALLIC MATERIALS[1]

A.S.T.M. Designation: E 9 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1924; REVISED, 1925, 1927, 1933.

Scope

1. These methods are intended to cover the compression testing of metallic materials.

Definition of Terms

2. The definitions of terms relating to compression testing in the Standard Definitions of Terms Relating to Methods of Testing (A.S.T.M. Designation: E 6)[2] and in the Tentative Definitions of Terms Relating to Methods of Testing (E 6 - 32 T)[3] of the American Society for Testing Materials, shall be considered as applying to the terms used in these methods of compression testing.

APPARATUS AND SPEED OF TESTING

Testing Machine Calibration

3. Testing machines used for compression testing shall conform to the requirements of the Tentative Methods of Verification of Testing Machines (A.S.T.M. Designation: E 4 - 33 T) of the American Society for Testing Materials.[4]

Speed of Operation of Testing Machine

4. In making compression tests of specimens of metallic materials the speed of the machine, by which is meant the speed of the cross-head when the machine is running idle, shall be such that the load can be accurately weighed, but in no case shall the speed be greater than the values given in the following table:

LENGTH OF SPECIMEN	MAXIMUM CROSS-HEAD SPEED, IN. PER MINUTE
1 in.	0.05
3 in. or over	0.10

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. H. F. Moore, Chairman of Technical Committee I on Mechanical Testing, of Committee E-1 on Methods of Testing, University of Illinois, Urbana, Ill.

[2] 1933 Book of A.S.T.M. Standards, Part I, p. 965.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 967 (1932); also 1933 Book of A.S.T.M. Tentative Standards, p. 1059.

[4] See p. 1033.

TEST SPECIMENS

Test Specimens

5. In recommending for use in compression tests the specimens described in Sections 8 to 12, it is not intended to exclude entirely the use of other test specimens for special materials or for special forms of material. It is, however, recommended that wherever it is feasible the specimens recommended be used.

Ends of Specimens

6. It is recommended that standard compression test specimens be in the form of circular cylinders. The ends of a specimen should be plane, as nearly as can be determined by the use of a straight edge and the unaided eye. In most cases this requirement necessitates the turning or the grinding of the ends of the specimen.

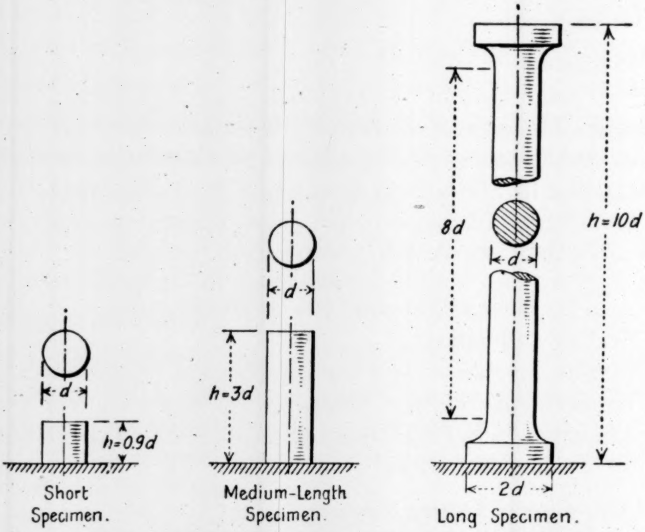

FIG. 1.—Test Specimens for Compression Tests.

Length of Specimens

7. Three classes of compression test specimens for metallic materials are recognized, designated as short specimens, medium-length specimens, and long specimens, respectively. Short specimens are used for compression tests of such metals as bearing metals, which in service are used in the form of a thin plate or shell to carry load perpendicular to the surface. Medium-length specimens are used for determining the general compressive strength properties of metallic materials. Long specimens are best adapted for determining the

modulus of elasticity in compression of metallic materials. In reporting the results of a compression test, it is important that the dimensions of the test specimen be given.

Dimensions of Specimens

8. The proportions of the three classes of compression test specimens are shown in Fig. 1. Suggested dimensions for compression test specimens for general use are as follows:

	DIAMETER, *d*	LENGTH, *l*
Short specimens	1⅛ in.[a] ±0.01 in.	1 in.
Medium-length specimens	0.798 in. ±0.01 in.	2⅜ in.
	1 in. ±0.01 in.	3 in.
	1⅛ in. ±0.01 in.	3⅜ in.
Long specimens	1¼ in. ±0.01 in.	12½ in.

---

[a] Area of cross-section is approximately 1 sq. in.

Measurement of Specimens

9. In all compression tests of metallic materials, the actual dimensions of cross-section of the test specimens shall be measured with a micrometer reading to 0.5 per cent of the dimension measured, and in any case to at least 0.001 in. The stress shall be calculated on the basis of the measured cross-section. It shall never be assumed that the dimensions of the cross-section of the specimen are identical with the nominal dimensions.

Finish of Specimens

10. Specimens shall be finished so that the surfaces are smooth and free from nicks and tool marks. All ragged edges shall be smoothed.

Bearing Blocks

11. (*a*) Both ends of a compression test specimen shall bear on carefully machined plane surfaces. The bearing blocks shall either be made of hardened steel, or shall be faced with hardened steel.

(*b*) One end of a compression test specimen shall bear on a spherical-seated compression block (Note). Figure 2 shows a satisfactory arrangement of compression specimen and bearing blocks. It is desirable that the spherical-seated bearing block be at the upper end of the test specimen (for specimens tested with the axis vertical). It is important that the center of the spherical surface of the spherical-seated bearing block shall be described by a radius having its point of origin in the flat face which bears on the specimen, otherwise lack of parallelism between faces of the specimen sets up a bending moment in the specimen.[1] It is also important that the specimen itself be carefully centered with respect to the center of this spherical surface within 0.01 in. in order to avoid eccentric loading on the specimen.

NOTE.—The device shown in Fig. 3 has been successfully used in compression tests of metallic specimens whose ends were machined with extreme care. It will be noted that this device does not involve a spherical-seated compression block bearing directly on the test specimen.[2]

(*c*) It should be borne in mind that the object of a spherical-seated bearing block is to give the specimen as even a distribution of initial load as is possible. Owing to friction, the spherical-seated bearing cannot be relied on to adjust itself to bending action which may occur during the test.

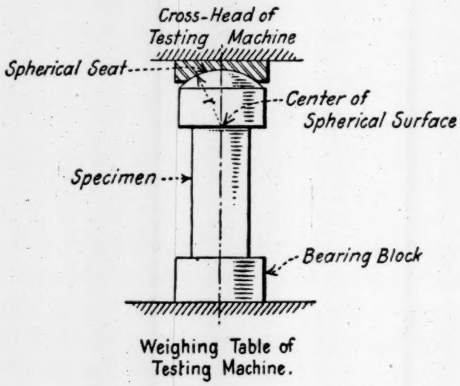
Cross-Head of Testing Machine
Spherical Seat
Center of Spherical Surface
Specimen
Bearing Block
Weighing Table of Testing Machine.

FIG. 2.—Spherical-Seated Bearing Block.

PROCEDURE

Cleaning Test Specimens

12. (*a*) The ends of the specimen and the faces of the bearing blocks shall be cleaned with acetone or similar solvent immediately before testing. This removes all grease or oil resulting from machining operations or from handling, and accordingly gives better bearing contact.

(*b*) Even though very careful procedure is followed in preparation, in the machining of specimens and in having well-made testing apparatus, the presence of a small amount of lubricant between the compression surfaces apparently permits of a differential lateral movement between the surfaces which causes a release in load or stress at that point, thus causing an effective eccentricity of loading which in turn gives rise to unsatisfactory failures in the tests of the specimens.

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[1] Mont Schuyler, "Spherical Bearings," *Proceedings*, Am. Soc. Testing Mats., Vol. XIII, p. 1004 (1913).

[2] This device or one similar has been successfully used in the British National Physical Laboratory and in the laboratories of the U. S. Air Service at Wright Field, Dayton, Ohio.

Care in Testing

13. In making compression tests, care shall be taken to preserve the alignment of the heads of the testing machine, and to center the specimen in the testing machine. The movable head of the machine shall be free from sidewise motion that is visible to the unaided eye as the machine is run at its fastest speed.

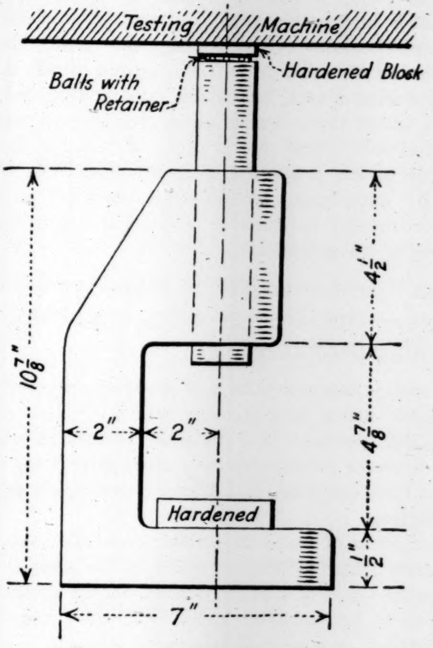

FIG. 3.—Compression Tool.

Determination of Proportional Limit, Elastic Limit, Yield Strength, Yield Point and Compressive Strength

14. The term "elastic limit" is defined as follows:

Elastic Limit.—The greatest stress which a material is capable of developing without a permanent deformation remaining upon complete release of the stress.

NOTE.—It is a matter of experience with many materials, especially with many metallic materials, that using ordinary methods of testing, the values found for elastic limit by means of observations of permanent deformation (set) after release of stress do not differ widely from the values found for proportional limit, the latter being defined as:

> *Proportional Limit.*—The greatest stress which a material is capable of developing without a deviation from the law of proportionality of stress to strain (Hooke's Law).
>
> Since the determination of proportional limit is much more readily made than is the determination of elastic limit, it is customary to accept the proportional limit as equivalent to the elastic limit for such materials, and hence the proportional limit is frequently called the "proportional elastic limit."
>
> In certain specifications of the Society, the term "Elastic Limit" is used to designate a value obtained by a test method which does not involve the release of stress during a test, but which does involve the determination of a limiting load at which there occurs an appreciable increase in rate of strain with respect to stress. This method may determine, for some materials, a satisfactory value of the proportional elastic limit, but the property termed "Yield Strength" determined by the "set method" as described below, is felt to be a more widely satisfactory and significant measure of the desired strength property of the material.

15. The term "yield strength" is defined as follows:

Yield Strength.—The stress at which a material exhibits a specified limiting permanent set.

NOTE.—It is usually impracticable and probably impossible to determine the stress at which inelastic action in a member *begins.* Plastic yielding in nearly all members (including the specimen in a carefully controlled laboratory test) starts as local actions and becomes measurable only after many local internal adjustments and accommodations have occurred, and after a considerable portion of the member is affected by the yielding.

The limit of usefulness of many materials, especially metals, in members subjected to approximately static loading at ordinary temperatures is therefore determined by a measurable value of plastic yielding of the material above which the material is considered to be damaged and below which the damaging effects are considered to be negligible.

The following methods are recommended for determining the yield strength of a material:

1. For material that has a "sharp-kneed" stress-strain diagram and hence exhibits at a certain stress the special characteristic of yielding without increase in stress. Two satisfactory methods are in use:

> (*a*) *The "Drop of the Beam" Method.*—In this method the load is applied to the specimen at a steady rate of increase and the operator keeps the beam in balance by running out the poise at approximately a steady rate. When the yield strength of the material is reached the increase of load stops, but the operator runs the poise a trifle beyond the balance position, and the beam of the machine drops for a brief but appreciable interval of time. In a machine fitted with a self-indicating load-measuring device, there is a sudden halt of the load-indicating pointer corresponding to the drop of the beam. The load at the "halt" or the "drop" is recorded, and the corresponding stress is taken

as the yield strength. This method of determining the yield strength requires only one man to conduct a test.

(*b*) *Total Strain Method Using Dividers.*—This method is frequently called the "dividers method." In this method an observer with a pair of dividers or other suitable apparatus, watches for visible elongation between two section marks on the specimen. When visible stretch is observed, the load at that instant is noted, and the stress corresponding to the load is taken as the yield strength.

Note on Yield Point.—The above two methods determine what is usually called the yield point which is commonly defined as follows:

Yield Point.—The stress in a material at which there occurs a marked increase in strain without an increase in stress.

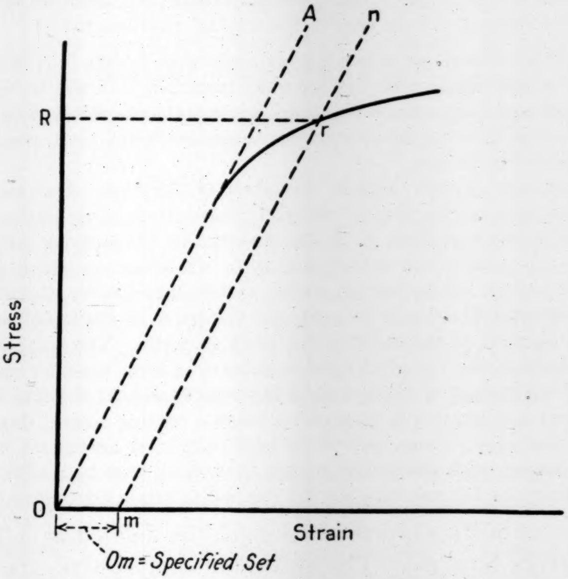

FIG. 4.—Stress-Strain Diagram.

It should be noted that only materials that exhibit this unique phenomenon of yielding have a yield point. The term yield point should not be used in connection with material whose stress-strain curve in the region of yield is a smooth curve of gradual curvature.

2. For material whose stress-strain diagram in the region of yield is a smooth curve of gradual curvature.

(*a*) *The Set Method.*—This method can be used, if desired, for materials having "sharp-kneed" stress-strain diagrams, but is especially adapted to materials whose stress-strain diagram in the yield range is a smooth curve of gradual curvature.

For nearly all materials, if at any point on the stress-strain diagram such as ***r*** in Fig. 4, the load is released the diagram for decreasing load will follow a line, ***rm***, approximately parallel to the initial portion, *OA*, of the diagram for increasing load. *Om* will then give the approximate value of the permanent set after the release of the stress *OR*. The value of this set is given in percentage of original gage length. Thus to determine the yield strength by the "set method," it is necessary to secure data (autographic or numerical) from which a stress-strain diagram may be drawn. Then with the stress-strain diagram (Fig. 4) lay off *Om* equal to the specified value of the set, and draw *mn* parallel to *OA* and thus locate *r*, the intersection of *mn* with the stress-strain diagram. Draw *Rr* parallel to the *X* axis and then *OR* gives the value of the yield strength.

In reporting values of yield strength obtained by this method, the specified value of "set" used should be stated in parenthesis after the term yield strength. Thus:

Yield strength (set = 0.1 per cent) = 52,000 lb. per sq. in. indicates that at a stress of 52,000 lb. per sq. in. the approximate permanent set of the material reached the value of 0.1 per cent of the original gage length.[1]

In using this method, an extensometer reading to 0.0001 in. per inch of gage length would be sufficiently sensitive for most materials. It will be observed that the elastic limit and proportional limit are special values of the yield strength in which the specified limiting set is not measurable with the instruments used and hence is considered to be zero.

(*b*) *Approximate Method Without Stress-Strain Diagram.*—For tests to determine the acceptance or rejection of material whose stress-strain characteristics are well known from previous tests of similar material in which stress-strain diagrams were plotted, the total strain corresponding to the stress at which the specified permanent set occurs will be known within satisfactory limits; therefore, in such tests a specified total strain may be used, and the stress on the specimen, when this total strain is reached, is the value of the yield strength. The total strain can be obtained satisfactorily by use of an extensometer or in some cases by use of dividers particularly if the surface of the specimen is prepared so that the line made by the dividers is a fine line and if it is observed through a reading glass. But it is recommended that this approximate method be used only after agreement between producer and consumer, with the understanding that check tests be made for obtaining stress-strain diagrams for use with the set method to settle any misunderstandings.

16. The term "compressive strength" is defined as follows:

Compressive Strength.—The maximum compressive stress which a material is capable of developing.

NOTE.—In the case of a material which fails in compression by a shattering fracture the compressive strength has a very definite value. In the case of materials which do not fail in compression by a shattering fracture the value obtained for compressive strength is an arbitrary value depending upon the degree of distortion which is regarded as indicating complete failure of the metal.

PLOTTING STRESS-STRAIN DIAGRAMS

17. The discussion and directions given in Section 28 of the Standard Methods of Tension Testing of Metallic Materials (A.S.T.M. Designation: E 8) of the American Society for Testing Materials[2] apply to plotting stress-strain diagrams for compression tests.

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[1] A value of 0.20 per cent of the gage length has been used rather widely for metals.

[2] 1933 Book of A.S.T.M. Standards, Part I, p. 949.

TENTATIVE METHODS
OF
ROCKWELL HARDNESS TESTING OF METALLIC MATERIALS[1]

A.S.T.M. Designation: E 18 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

Issued, 1932; Revised, 1933.[2]

The Rockwell hardness tester is essentially a machine that measures hardness by determining the depth of penetration of a penetrator into the specimen under certain arbitrarily fixed conditions of test. The penetrator may be either a steel ball or a diamond sphero-conical penetrator. The hardness value, as read from the dial, is an arbitrary number which is related to the depth of indentation and since the scales are reversed, the number is higher the harder the material. A minor load of 10 kg. is first applied which causes an initial penetration which sets the penetrator on the material and holds it in position. The dial is set at zero on the black-figure scale, and the major load is applied. This major load is customarily 60 kg. or 100 kg. when a steel ball is used as a penetrator, but other loads may be used when found necessary, and usually 150 kg. when a diamond sphero-conical penetrator is employed. The ball penetrator is $\frac{1}{16}$ in. in diameter normally but other penetrators of larger diameter such as $\frac{1}{8}$ or $\frac{1}{4}$ in. may be employed for soft metals. A variety of loads and penetrators are thus provided and experience decides the best combination for use.

After the major load is applied and removed, according to standard procedure, the reading is taken while the minor load is still in position.

APPARATUS

Rockwell Scales

1. Rockwell hardness values shall be determined and reported according to one of the following standard scales. In all cases the minor load shall be 10 kg. and the dial shall be adjusted after applying the minor load so that the pointer reads at "SET" (B 30).

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. J. R. Townsend, Chairman of the Section on Indentation Hardness Testing of Committee E-1 on Methods of Testing, Bell Telephone Laboratories, Inc., 463 West Street, New York City.

[2] Revision accepted by Committee E-10 on Standards, August 16, 1933.

	PENETRATOR	MAJOR LOAD	SCALE TO USE FOR READING HARDNESS VALUES	LETTER TO PREFIX TO HARDNESS READING TO DESIGNATE SCALE
A Scale	diamond	60 kg.	Black figures	A
B Scale	$\frac{1}{16}$-in. ball	100 kg.	Red figures	B
C Scale	diamond	150 kg.	Black figures	C
D Scale	diamond	100 kg.	Black figures	D
E Scale	$\frac{1}{8}$-in. ball	100 kg.	Red figures	E
F Scale	$\frac{1}{16}$-in. ball	60 kg.	Red figures	F
G Scale	$\frac{1}{16}$-in. ball	150 kg.	Red figures	G

NOTE.—In order to cover the entire range of hardness found in various metallic materials, it has been found useful to use the above combinations of penetrators and loads which are all available with the Rockwell hardness tester. There is no Rockwell hardness value designated by a figure alone because it is necessary to indicate which penetrator and load has been employed in making the test.

The dial of the machine has two sets of figures, one red and one black, which differ from each other by thirty hardness numbers. The dial was designed in this manner to accommodate the B and C scales which were the first ones standardized and which are also very widely used. Two advantages were gained by this shifting of the zero points; first, negative numbers were avoided on soft material such as brass, when tested on the B scale; and second, this established B 100 at the upper practical limit of hardness that might be tested with the 100-kg. major load and the $\frac{1}{16}$-in. ball without deforming the ball.

In the above designations of scales, it will be noted that the red figures are used for readings obtained with ball penetrators regardless of size of ball or magnitude of major load, and that black figures are used only for the diamond penetrator with various loads.

The applications of the various scales and their limitations are as follows:

A Scale, for testing tungsten carbide and other extremely hard materials which might cause chipping of the diamond penetrator under higher loads; also for thin hard sheets such as razor-blade stock.

B Scale, for testing materials of medium hardness such as low- and medium-carbon steels in the annealed condition. The working range of this scale is from B 0 to B 100. If the ball penetrator is used to test material harder than about B 100, there is danger that it will be flattened. Furthermore, because of its shape, the ball is not as sensitive as the sphero-conical penetrator to small differences in hardness on hard specimens. If the $\frac{1}{16}$-in. ball is used on material softer than B 0, there is danger that the cap of the penetrator which holds the ball in place will rest on the specimen, or that the weight arm will descend too far and rest on its stop pin. Below B 0 the $\frac{1}{16}$-in. ball, due to its shape, becomes supersensitive and the readings are erratic because errors and effects of non-homogeneity become unduly magnified.

C Scale, is the one most commonly used for materials harder than B 100. The hardest steels run from C 65 to C 70. The useful range of this scale is from C 20 upwards. Any inaccuracies which occur in grinding the diamond penetrator to its proper shape become enlarged at the base of the cone, and it should therefore not be used below this lower value. Due to this fact, the manufacturer does not check the accuracy of the penetrators for readings below C 20. On soft materials the spherical apex (0.2 mm. radius) of the diamond penetrator is driven into the material a considerable amount by the minor load and unless the speed of contacting the penetrator against the work and the time interval between applying minor and major loads is standardized, there will be considerable variation in the readings from this cause. This is negligible when using the diamond penetrator on harder material.

D Scale, can be used when a somewhat lighter load is desirable than that used with the C scale. This is sometimes useful on case-hardened pieces.

E Scale, is useful for testing very soft materials such as bearing metals.

F Scale, covers about the same range in hardness as the E scale, but uses a $\frac{1}{16}$-in. ball.

G Scale, is used with metals harder than the B scale.

The useful ranges of the various scales have been described but there may be cases in which more than one scale could be used and yet comply with these methods, and in such instances it is desirable to employ the smallest ball that can properly be used, because of the loss of sensitivity as the size of the penetrator increases. An exception to this is when soft non-homogeneous material is to be tested, in which case it may be preferable to use a larger ball which makes an impression of greater area, thus obtaining more of an average hardness.

Penetrators

2. The standard penetrators, as have been described in Section 1, are the diamond sphero-conical penetrator and steel balls of $\frac{1}{16}$-in. and $\frac{1}{8}$-in. diameter. The shape of the diamond sphero-conical penetrator shall be a cone forming a 120-deg. angle with a spherical apex of 0.2 mm. radius. The steel balls used shall be free from surface imperfections (Note). The diameter of the balls shall not deviate from the nominal value more than ±0.00002 in. and the diameter of any ball measured at various points shall be constant within a tolerance of ±0.00002 in.

NOTE.—An occasional check of the accuracy of the penetrator's contour should be made by examination with a magnifying glass. This will reveal any chipping of the diamond or flattening of a ball penetrator. If either of these conditions are discovered, the remedy is to have the diamond reground and to replace the flattened ball with a new one. Dust, dirt, grease, and scale shall not be allowed to accumulate on the penetrator as this will affect the results.

Anvils

3. An anvil shall be used which is suitable for the specimen to be tested. Cylindrical pieces shall be tested with a V-notch anvil which will support the specimen with the axis directly under the penetrator. Flat pieces shall be tested on a flat anvil which has a smooth flat bearing surface whose plane is perpendicular to the axis of the penetrator. For thin materials or specimens (Note 1), which are not perfectly flat, this flat anvil shall have a small elevated "spot" about $\frac{3}{16}$ in. in diameter and about $\frac{1}{8}$ in. in height (Note 2). This

spot shall be polished smooth and flat and shall be free from pits and heavy scratches. This spot shall have a hardness of at least C 60.

NOTE 1.—If the provisions of Section 5 on thickness of specimen are complied with, there will be no danger of indenting the anvil, but if the specimen is so thin that the impression will show through on the under side, it is possible that the anvil may be damaged. Damage may also occur from accidental contacting of the anvil with the penetrator. If the anvil is damaged from any cause, it should be replaced with a good one. Anvils showing the least perceptible dent will give inaccurate results on thin material.

NOTE 2.—Very soft material should not be tested on the "spot" anvil because the applied load may cause the penetration of the anvil into the under side of the specimen regardless of its thickness.

Test Blocks

4. (*a*) Test blocks used for checking the accuracy of the Rockwell tester shall be of uniform material, thick enough to be free from "anvil effect," of smooth surface on both top and bottom sides and of not more than 4 sq. in. surface area on the test surface (Note). They shall be free from surface imperfections that might affect the hardness readings.

(*b*) The hardness value of a test block shall be determined by making five impressions with a Rockwell tester of accepted accuracy, using the procedure described in Section 6. These impressions shall be made near the center and four corners of the test block. The total spread of these five hardness values shall not be more than 2 hardness numbers for blocks of B 30 or greater hardness, nor more than 3 hardness numbers for blocks softer than B 30. The average of the five readings shall be taken as the true Rockwell hardness of the test block. The test blocks shall be marked with a range of values which will include all five of the readings.

NOTE.—Test blocks should be used only on the test surface because this is the only one that has been checked on the machine of accepted accuracy. Moreover, each impression has a small ridge around it, and if the block is tested on its reverse side, these ridges tend to be flattened under the pressure of the major load and may result in a low reading. Blocks should not be reground or otherwise resurfaced after they have been used up, because it is the *top* surface that was originally standardized and this may be of a different hardness from the new surface. The impressions work-harden the block to a considerable depth and this may result in the new test surface being in a work-hardened condition and not of the same hardness as the original test surface.

Test blocks should be available for checking the Rockwell tester at those points over its range at which material is being tested. This will depend on the individual user's requirements.

TEST SPECIMENS

Specimens

Specimens used in Rockwell hardness testing vary greatly in form since it is frequently desirable to make the impression upon a part to be used in the finished product rather than upon a sample test specimen.

5. (*a*) The thickness of the piece tested shall be such that no bulge or other marking showing the effect of the load appears on the surface of the piece opposite the impression (Note 1).

(*b*) The test surface at the point of test shall be free from all scale, oxide films, pits, and foreign material that may affect the results (Note 2). The bottom surface shall be free from scale, dirt, or other foreign material that might crush or flow under the test pressure and so affect the results. Galvanized, "alloy," paint, or other coatings shall be removed before making a test of the hardness of the base metal (Note 3).

(*c*) All Rockwell hardness tests shall be made on a single thickness of the material, regardless of thickness (Note 4).

NOTE 1.—The above requirement for minimum thickness is based on the experimental fact that below a certain minimum thickness the depth of the impression is noticeably affected by the supporting anvil. This minimum thickness depends upon the nature of the material and in some cases it has been found that even though the impression shows through slightly, the Rockwell value is not noticeably affected. Due, however, to the limited amount of data available on various materials, it is not believed to be expedient at this time to set any lower limits of minimum thickness than those given above. If, for special experimental purposes, it is desirable to make tests on material so thin that the impressions show through, then this fact should be stated in reporting the results and the thickness of the piece should also be given.

As a matter of information, it may be stated that tests on annealed commercially pure iron of B 35 Rockwell hardness showed that the readings were not affected down to a minimum thickness of 0.040 in. although the impressions showed through on material 0.060 in. or under in thickness.

The manufacturers of the Rockwell machine state that for the E scale, material harder than E 60 may be tested as thin as $\frac{1}{8}$ in., but if softer than E 60, the minimum thickness should be $\frac{3}{16}$ in.

NOTE 2.—The effect of the surface condition of the specimen on the results of the test indicate that the specimen should be clean, bright and dry. A pitted surface may give erratic readings due to some impressions being made near the edge of a depression. This permits a freer flow of metal around the indenting tool and will result in a low reading. Oiled surfaces will generally give slightly lower readings than dry ones because of the reduced friction under the penetrator. Light yellow water rust on ferrous metals has been found to raise the readings as much as one or two hardness numbers due probably to increased friction under the penetrator. Scale and oxide films produce varying effects. If a heavy scale supports both the minor and major loads, the readings will be high. If it is crushed by the major load, the readings will be low. If some of the scale remains under the penetrator or "pops off" and allows the penetrator to sink that much lower into the specimen, the readings will be variable. If the specimens are thin enough to show any trace of the impression on the under side, then the surface condition under the impression may affect the results.

NOTE 3.—In removing surface films, and other imperfections, care must be taken not to change the hardness of the material by cold working or by undue heating. Galvanized or paint coatings can be removed by suitable solvents or chemicals. In the latter case, roughening of the test surface from prolonged attack of the chemical should be avoided. Scale, rust, pits or other undesirable surface conditions can be remedied by careful filing or grinding. Surface oxidation shall be removed by rubbing lightly with a suitable abrasive. Light cuts in a suitable machine tool can be resorted to if necessary, but deep tool marks or heavy grinding scratches may affect the results and should be avoided.

NOTE 4.—The requirement in Paragraph (*b*) is essential because experience has shown that tests made on more than one thickness are unreliable. The use of more than one thickness is only resorted to, as a rule, in the case of material which is so thin that the impression made on a single thickness will show through on the under side. The use of additional thicknesses of the same material under the "test piece" does not give at all the same effect as a solid piece of the same thickness as the combined pieces. Flow takes place on the surfaces between the various pieces and the amount of this varies with the condition of these surfaces. Another large source of error is due to the lack of flatness of the separate pieces which leads to a compression of the pile under the major load. This is partly elastic and partly permanent set and introduces an unknown factor into the test.

Procedure

6. (*a*) Before using the machine, its accuracy shall be determined as described in Section 8.

(*b*) The machine shall be adjusted according to the methods described in Section 7.

(*c*) A suitable scale shall be selected and the proper load and penetrator used in accordance with Sections 1 and 2.

(*d*) A suitable anvil shall be selected in accordance with Section 3.

(*e*) *Minor Load Application.*—The piece to be tested, after being prepared according to Section 5, shall be placed on the anvil and the minor load applied *gradually* until the proper dial indication is obtained. This shall be understood to be when the pointer has made the proper number of complete revolutions and stands within ±5 divisions of the "SET" position at the top of the dial. The proper number of complete revolutions shall be indicated either by a reference mark on the stem of the gage or by an auxiliary hand on the dial. In bringing the penetrator and work into contact all impact shall be avoided, and the last movement of the elevating or lowering screw shall always be in a direction which will bring penetrator and work together. If the proper setting is over-run, the minor load shall be removed and a new spot selected for the test. After the minor load has been applied, the dial pointer shall be set at zero on the black-figure scale.

(*f*) *Major Load Application.*—In applying the major load, the operating handle shall be allowed to move without interference until the major load is completely applied. This shall be determined in either of two ways, (*1*) when the pointer suddenly slows down, or (*2*) when the weight arm is completely free from the control of the dash pot. When the major load has been completely applied, the operating handle shall be immediately brought gently back to its latched position; this shall be accomplished within 2 seconds after the major load has been completely applied.

(*g*) *Reading Scale for Rockwell Hardness.*—The Rockwell hardness shall be taken as the reading of the pointer on the proper dial figures after the major load has been removed and while the minor load is still applied. All readings shall be prefixed by a letter showing which scale was used as described in Section 1.

ADJUSTMENT AND CALIBRATION OF ROCKWELL HARDNESS APPARATUS

Adjustments

7. (*a*) *Speed of Load Application.*—The dash pot on the Rockwell tester shall be so adjusted that the operating handle completes its travel in from 4 to 5 seconds with no specimen on the machine and with the machine set up to apply a major load of 100 kg.

(*b*) *Index Lever Adjustment.*—The following tests (and adjustments, if necessary) shall be made as follows: Place a piece of material on the anvil and turn the capstan elevating nut to bring the material against the penetrator. Keep turning to elevate the material until the hand feels positive resistance to further turning, which will be felt after the 10-kg. minor load has been picked up and when the major load is encountered. When excessive power would have to be used to raise the work higher, take note of the position of the pointer on the dial, after setting the dial so that C 0 and B 30 are at the top. Then if the pointer stands between B 50 and B 70 no adjustment is necessary; if the pointer stands between B 45 and B 50, adjustment is advisable; and if the pointer stands anywhere else, adjustment is imperative. As the pointer revolves several times when the work is being elevated, the readings mentioned above apply to that revolution of the pointer which occurs either as the reference mark on the gage stem disappears into the sleeve or as the auxiliary hand on the dial passes beyond the zero setting on the dial. The object of this adjustment is to see that the elevation of the specimen to pick up the minor load shall not be carried so far as to cause even a partial application of the major load, which to make a proper test, shall be applied only through the release mechanism.

The adjustment of the index lever, if necessary, shall be made as follows: When the test piece is elevated until it starts to pick up the major load, loosen the lock nut of the screw through the index lever which carries at its lower end a small steel plate engaging the ball on the penetrator shaft, while using a small screw driver to firmly hold the screw until after the nut is loose. Then turn the screw very slightly and note the result on position of the gage pointer which should be between B 60 to B 70 before reclamping the screw with its lock nut.

Calibration with Test Blocks

8. (*a*) A test block shall be selected as near as possible to the hardness of the material being tested (preferably within ±5 hardness numbers). Five impressions on the test surface of the block shall be made and the average thereof compared with the average of the five readings made in establishing the hardness value of the block. The difference between these two averages shall be taken as the error of the machine, and the readings in this portion of the scale corrected accordingly. If the error is more than ±2 hardness numbers (Note 1), the machine shall be conditioned and brought into adjustment until it comes within this limit before it is used.

(*b*) In the case of inspection of material between a producer and a consumer (Notes 2 and 3), the producer and consumer shall agree upon the standard test blocks to be used in checking and calibrating the Rockwell machines used.

NOTE 1.—It has been found practicable to keep Rockwell testers within ±2 hardness numbers of the correct readings over the range B 35 to B 70, but a somewhat wider range prevails for softer materials. When machines in everyday production inspection testing are calibrated and adjusted once a month, it has been found that they very seldom deviate more than this amount. Daily checking of such machines merely assures the operator that the penetrator is in good condition and the machine is operating properly. The trend of the readings on test blocks on the daily check tests is compared with the last monthly calibration and as long as the machine does not deviate noticeably from this, no corrections are applied when it is used for routine testing.

NOTE 2.—When referee tests are to be made, the machine should be carefully gone over and all adjustments checked before calibrating it as described above. If readings of high accuracy are necessary, the machine may be calibrated before and after making the tests. If the machine has the same error both times, it can be safely assumed that the correction for this error will give the true Rockwell hardness, except under the conditions described in the following Note 3.

NOTE 3.—Due to the fact that surface conditions have a marked effect on the readings obtained on thin materials and due to the fact that the thickness of such specimens may influence the results, it cannot be assumed that the indications on the standard blocks furnish any reliable measure of the errors to be expected when testing thin material. Standard blocks are always thick enough to eliminate the effect of the underlying anvil and this is as it should be. But it must be remembered that errors of unknown magnitude may occur when tests are made on material which is thin enough for the impression to show through on the reverse side. The standard test blocks will indicate the errors of the machine when used to test specimens of similar size, shape, and surface condition, but there is at the present time no satisfactory way of checking the accuracy of the readings taken on such thin material nor of evaluating the anvil effect when this is present.

PRECAUTIONS

9. (*a*) *Protection Against Vibration.*—If the bench or table on which the Rockwell hardness tester is mounted is subject to vibration, such as experienced in the vicinity of other machines, the tester should be mounted on a metal plate on sponge rubber at least 1 in. in thickness or any other type of mounting that will effectually eliminate vibration from the machine. Otherwise the penetrator will penetrate farther into the material than when such vibrations are absent.

(*b*) *Cushioning of Latch.*—If, when the operating handle is being returned to its normal position, the latch operates with such a snap as to noticeably change the position of the dial pointer, felt or rubber washers should be placed under the trip mechanism in order to cushion this blow. If this snap is severe, difference in reading of several hardness numbers may result.

(*c*) Specimens employed for hardness determinations shall be prepared with care. Should sheet metal be employed, special care should be taken with material that is curved. The concave side of the curved metal should face toward the penetrator. If such specimens are reversed, an error will be introduced due to the flattening of the metal on the anvil.

(*d*) Specimens which have sufficient overhang so that they do not balance themselves on the anvil shall be properly supported.

(*e*) The penetrator and anvil should not be brought together without a test piece between them, otherwise the anvil will be indented and the ball flattened.

(*f*) The dial gage plunger shall move free without appreciable change of friction in any position.

(*g*) The time of application of the major load shall be established and accurately adhered to when comparing results. As a general rule, an interval of full application of the major load of not more than one second is best. For soft metals the penetration will "creep," causing variations as high as 10 hardness numbers. With such metals the operating lever should be brought back the moment it is seen that the major load is fully applied.

TENTATIVE METHODS OF IMPACT TESTING OF METALLIC MATERIALS[1]

A.S.T.M. Designation: E 23 – 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1933.[2]

Scope

1. (*a*) These methods of notched-bar impact tests are intended for comparison of the brittleness of metals. The impact test consists of the determination of the energy absorbed in fracturing an arbitrarily notched specimen by a single blow of a calibrated pendulum. The tests are based on the assumption that resistance to shock depends upon the ability of materials rapidly and safely to equalize dangerously concentrated stresses by plastic flow or equivalent action. The specimen is notched to produce an intense concentration of stress as a test condition and the notch is therefore a necessary feature of the specimen unless the inherent structure of the material to be tested is such as to produce an equivalent internal condition.

(*b*) The indications of the test shall be stated only in terms of the total energy required to break a standardized specimen under standardized conditions and cannot be generalized and applied quantitatively to other sizes of test pieces or other conditions. Unless specifically supported in a particular case, the interpretation of results shall be restricted within the established limitations of the test as indicated in the Appendix.

Mechanics of the Test

2. The essentials of an impact test are (*1*) a suitably notched specimen, (*2*) a moving mass of known kinetic energy which must be great enough to cause fracture of a test specimen placed in its path, (*3*) an anvil or support on which the test specimen is placed to receive the blow of the moving mass, and (*4*) a device for measuring the residual energy in the moving mass after the specimen has been broken. Many different arrangements of these elements are possible and may yield satisfactory individual comparisons. For standardized

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. W. W. Werring, Chairman of the Section on Impact Testing, of Committee E-1 on Methods of Testing, Bell Telephone Laboratories, 463 West St., New York City.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 16, 1933.

results the essential features are the specimen and its manner of support and fracture.

3. Two methods of holding and striking the specimen are recognized as standard, (*a*) the Charpy test and (*b*) the Izod test.

(*a*) *Charpy Test.*—In the Charpy test the specimen is held as a simple beam (usually horizontal) and is broken by a single blow delivered midway between the supports.

(*b*) *Izod Test.*—In the Izod test the specimen is held as a cantilever beam (usually vertical) and is broken by a blow delivered at a fixed distance from the edge of the specimen clamp.

4. (*a*) The Charpy type test may be made on unnotched specimens if indicated by the characteristics of the material tested but the Izod type test is not suitable for other than notched specimens.

(*b*) In both types of test the specimen shall be struck so that the root of the notch is in the region of the tensile beam stress.

APPARATUS

General Requirements

5. (*a*) The machines used shall be of the pendulum type of rigid construction and of capacity sufficient to break the specimen in one blow. They shall be accurate to within 1 per cent of their calibrated capacity. The machine shall be so scaled that definitely indicated and accurate corrections may be made for friction and windage losses.

(*b*) The dimensions of the machine shall be such that the center of percussion of the striker, as defined under Sections 23 and 24, is at or only slightly above the point of impact, that is, the center of the striking edge.

(*c*) The pendulum shall be released from such a position that the linear velocity of the center of the striking edge at the instant of impact shall be at least 11 ft. per second, which is that corresponding to an initial elevation of the center of the striking edge of 2 ft. As velocity effects appear to be present in some materials and differ with the material, it may be necessary in arbitration tests to agree upon a particular velocity.

(*d*) Means shall be provided for determining the impact strength. The impact strength shall be taken as the energy absorbed in breaking the specimen and is equal to the difference between the energy in the pendulum blow at the instant of impact with the specimen and the energy remaining in the pendulum after breaking the specimen.

NOTE.—An impact machine will be inaccurate to the extent that any energy used in deformation or movement of its component parts will be registered as used in fracturing the specimen. A machine faulty in this respect will yield readings higher than the true value. The machine should, therefore, be substantially and rigidly constructed with no looseness or play in any part.

Simple Beam Apparatus (Charpy Type Test)

6. (*a*) Means shall be provided to support the test specimen against two rigidly mounted blocks in such a position that its center of gravity shall be on a tangent to the arc of travel of the striking point of the pendulum drawn at the position of impact.

(*b*) The points of support shall be 1.575 in. (40 mm.) apart. The space through which the breaking specimen is forced shall not decrease in width back of the supports and preferably should increase.

(*c*) Means shall be provided on the machine or by use of a separate gage for accurately locating the specimen so that the center line of the notch is midway between the supports.

(*d*) The center line of the striking edge shall swing in a plane midway between the supporting edges of the specimen anvils. It shall be so curved and aligned as to make contact at the center of the width of the specimen.

Cantilever Beam Apparatus (Izod Type Test)

7. (*a*) Means shall be provided for clamping the specimen rigidly in such position that the face of the specimen to be struck lies in the plane established by the striking edge in the impact position and the center of rotation. The edges of the supporting surfaces shall be sharp 90-deg. angles, and shall be in a plane 0.866 in. ± 0.005 in. (22 mm. ± 0.127 mm.) vertically below the center of the striking edge in the striking position and parallel to the tangent to its arc of rotation. The clamping surfaces shall be smooth and exactly parallel so as to clamp the specimen firmly up to the notch. The specimen shall be held parallel to a line through the center of rotation and the striking edge.

(*b*) The striking edge shall be an edge formed in the position of impact by the intersection of a plane inclined at an angle of 5 deg. away from the face of the specimen and another plane perpendicular to the specimen. It shall be rounded to a radius of $\frac{1}{16}$ in. and shall be so aligned as to make contact across the full face of the specimen.

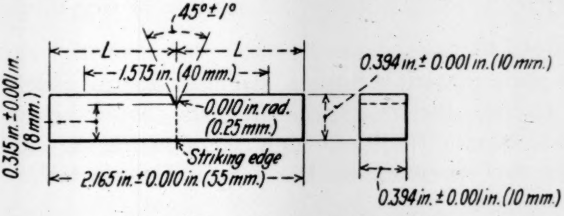
TEST SPECIMENS

Test Specimens

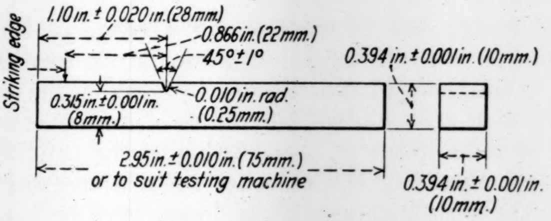
8. (*a*) All test specimens shall be finished to the final outside dimensions shown in Fig. 1 (*a*) and (*b*) by grinding or other processes

resulting in an equivalent smoothness of finish. Final machining marks shall be in the longitudinal direction, at least in the vicinity of the notch. The notch shall be cut with a special formed milling cutter provided solely for the purpose or in the case of very hard materials by grinding.

(*b*) If specimens are stamped for identification, such stamping shall be on the ends of specimens so as not to affect the clamping or support of the specimen. All stamping shall be done prior to notching to avoid cold deforming of the metal at the root of the notch.


45°±1°
L
L
1.575 in. (40 mm.)
0.394 in. ± 0.001 in. (10 mm.)
0.315 in. ± 0.001 in. (8 mm.)
0.010 in. rad. (0.25 mm.)
Striking edge
2.165 in. ± 0.010 in. (55 mm.)
0.394 in. ± 0.001 in. (10 mm.)

(*a*) Simple beam (Charpy type) specimen.


1.10 in. ± 0.020 in. (28 mm)
0.866 in. (22 mm.)
45°±1°
0.394 in. ± 0.001 in. (10 mm.)
Striking edge
0.315 in. ± 0.001 in. (8 mm.)
0.010 in. rad. (0.25 mm.)
2.95 in. ± 0.010 in. (75 mm.) or to suit testing machine
0.394 in. ± 0.001 in. (10 mm.)

(*b*) Cantilever beam (Izod type) specimen.

FIG. 1.—Impact Test Specimens.

(*c*) The choice of specimens depends to some extent upon the characteristics of the materials tested. A given specimen may not be equally satisfactory for soft non-ferrous metals and hardened steels but the specimens shown in Fig. 1 are those most widely used and most generally satisfactory, particularly for the ferrous metals. Accuracy of results requires that specimens be held to the dimensional tolerances shown in Fig. 1.

PROCEDURE

General Precautions

9. (*a*) Before a specimen is placed in position to be tested the machine shall be put in proper adjustment to avoid excessive friction in the pendulum bearings or drag of the recording devices. The method of adjustment will depend upon the design of the machine, but a properly adjusted machine of 120-ft-lb. capacity should not

lose more than 0.5 ft-lb. of energy while swinging back as far as it will go toward the initial position and then returning again to the final position, that is, in making an additional complete oscillation after a free swing.

(*b*) The friction of the recording devices shall be the minimum that will prevent over-carrying of the indicator or dropping back with the pendulum.

(*c*) The mechanism for releasing the pendulum from its initial position shall operate freely and permit release of the pendulum in a free start without initial impulse, retardation or side vibration.

Temperature of Testing

10. In some materials impact strength varies widely with temperature. Unless otherwise specified, tests should be made at 70 F. (21 C.). For specific results at high temperatures care must be taken to maintain the specimen at the required temperature up to the moment of impact.

Friction Correction

11. The energy lost in friction and windage of the pendulum and in friction in the recording mechanism, if not corrected for, will be included in the energy loss attributed to breaking the specimen and therefore result in erroneously high values of impact strength. The total value of these losses on a full swing of the pendulum may be determined by operating the machine as in a test but without a specimen. The distribution of these losses may be determined by the methods of calibration described in Sections 15 to 26. Detailed correction need not be made unless differences are indicated which are of significant magnitude relative to the value of impact strength determined and the capacity of the machine.

Location of Test Specimen

12. It is essential that the test specimens be placed in proper position in the machine (Section 13 (*b*) and (*c*)) and that the dimensional relations of notch, supports and striking edge be fixed by the use of gages made with the greatest precision obtainable in tool room practice. A detectable error in notch position relative to the parts of the machine involved may be considered a probable cause of inaccurate results.

Operation of Machine

13. (*a*) With the specimen properly located in the machine the indicator shall be set at the initial position and the pendulum smoothly released from its initial position.

(*b*) *Simple Beam Method.*—The Charpy type test specimen shall be struck on the side opposite the notch while supported against the supporting blocks in such a position that the center line of the striking edge strikes exactly in line with the center line of the notch which shall be midway between the points of support.

(*c*) *Cantilever Beam Method.*—The Izod type test specimen shall be struck on the notched face at a point 0.866 in. ± 0.005 in. (22 mm. ± 0.127 mm.) from the center line of the notch while gripped in such position in the support vise that the center line of the notch is exactly in line with the line of support over which the specimen will be bent during fracturing.

(*d*) If any specimen fails to break, the blow shall not be repeated but the fact shall be recorded indicating whether the failure to break occurred through extreme ductility or lack of sufficient energy in the blow. Such results cannot be averaged.

Report of Test

14. The report of the test shall include the following:

(*a*) Whether simple beam or cantilever beam method was used;
(*b*) Whether the specimen used was notched or unnotched;
(*c*) The initial energy of the blow;
(*d*) The energy actually absorbed by the specimen in breaking, reported in total foot pounds;
(*e*) The number of specimens failing to break (Section 13 (*d*));
(*f*) The calculated velocity of the hammer at the instant of striking based on the initial height of the striking edge as given under Section 25; and
(*g*) The temperature of the specimen or of the room conditions if both are the same.

CALIBRATION

General Considerations

15. (*a*) Impact strength, as defined in Section 5 (*d*), is equal to the difference between the energy in the pendulum before and after impact.

(*b*) The energy of the pendulum both immediately before and immediately after breaking the specimen is kinetic energy and its value depends upon the mass of the pendulum and its rotational velocity. The difference in energy which it is desired to determine is represented by a decrease in rotational velocity.

Theoretic Basis of Calibration

16. The determination of energy values experimentally from the respective velocities would be extremely difficult but a simpler

basis of calibration is available. Neglecting losses, the kinetic energy of the pendulum at the instant of impact results from and is equal to the potential energy possessed by the pendulum at its initial elevation. Similarly, and again neglecting losses, the kinetic energy of the pendulum immediately after breaking the specimen results in and is equal to the potential energy acquired by the pendulum at the maximum elevation to which it swings after breaking the specimen. The energy absorbed by the specimen, or the impact strength, neglecting friction, vibrational or other losses, is therefore the difference in the energy of elevation of the pendulum in its initial position and in the position it attains after breaking the specimen. The calibration of a pendulum type machine may therefore be based upon the total weight of the pendulum and the elevation of the center of gravity above its lowest position. The product of the total weight in pounds and the elevation in feet gives the energy in foot pounds.

17. The location of the center of gravity may readily be determined by well-known methods. The center of gravity is, however, a theoretical point in the interior of the pendulum and in some designs it may be a point in space. The practical difficulties of measurement to this physically indefinite point may be avoided and the energy, that is, the product of the total weight and the elevation of the center of gravity may be determined experimentally without determining either value separately. The procedure is based upon the following considerations:

(*a*) Correct design requires that the striking edge be so located in the pendulum as to lie on the extension of a line drawn through the center of rotation and the center of gravity. Consider such a pendulum of total weight W and with its center of gravity at a distance R_g from the center of rotation. When moved from the position of rest through an angle α, the center of gravity rises a distance H_g. Then:

$$H_g = R_g - R_g \cos \alpha \quad \text{or} \quad H_g = R_g \,(1 - \cos \alpha)$$

The potential energy at this position will be:

$$E = WR_g \,(1 - \cos \alpha)$$

(*b*) If now the pendulum is considered supported in this position by a vertical force W' applied at any other point on the line through the center of rotation and the center of gravity at a distance R' from the center of rotation, equilibrium requires equality of moments or:

$$WR_g = W' R'$$

and therefore

$$E = W'R' (1 - \cos \alpha)$$

(*c*) Since the term $R'(1-\cos\alpha)$ represents the change of elevation of the particular point of application chosen for this new vertical force, it is possible to base the calibration upon the changes in elevation of any arbitrarily chosen point on the pendulum provided the corresponding value of reaction force or weight is used. Since the center of the striking edge is the most definitely located point on the pendulum experimental calibration should be based upon it.

EXPERIMENTAL PROCEDURE

Striking Edge Adjustment

18. The machine shall be placed exactly level and the pendulum allowed to come to rest hanging unrestrained in its bottom position. The striking edge should then coincide with a vertical line through the center of rotation. Should any measurable divergence be observed the position of the striking edge in the head of the pendulum shall be corrected by appropriate measures. In the case of machines having replaceable striking edges this is readily accomplished by removing metal or adding shims at the back of the striking edge or by complete replacement of the striking edge.

Calibration Weight of Pendulum

19. (*a*) The pendulum, complete with all moving parts, shall be supported in a horizontal position with two supports; one at the bearings (or center of rotation) and the other at the center of the striking edge. The support at the striking edge shall be arranged to react upon some suitable weighing device such as a platform scale or balance and the weight accurately determined. Care shall be taken to avoid excessive friction at either point of support. Contact should be made with the striking edge through a round rod crossing the edge at a 90-deg. angle.

(*b*) The final weight shall be determined by averaging the weight at which the pendulum begins to move upward and that at which it begins to move downward, proper allowance being made for weight of supports, etc.

(*c*) The required sensitivity of the weighing device and the accuracy of the determination will depend upon the capacity of the machine and may be calculated from the fact that the weight determined enters as a first power factor in the energy values.

Initial Energy of Blow

20. (*a*) The changes in elevation of the center of the striking edge may be determined by direct measurement from a fixed level on the machine by means of suitable height gages. If available, a cathetometer will be found useful for this purpose.

(*b*) The initial energy of blow in foot pounds will be the product of the calibration weight (as determined in Section 19) in pounds and the change in elevation of the center of the striking edge in feet when the pendulum is raised to the initial position for a test.

Scale Readings

21. (*a*) The pendulum shall be moved by hand through the striking position with the indicator mechanism operating as in a test. With the indicator at various readings on the scale, the pendulum shall be supported and the height of the center of the striking edge above the impact position shall be measured. The height in feet multiplied by the calibrated weight, in pounds, gives the residual energy of the pendulum when actually in this position.

(*b*) When the residual energy is subtracted from the energy at the instant of impact the result is the correct impact strength that should be indicated on the scale, at that position, neglecting friction corrections.

Friction and Windage Correction

22. (*a*) Precise friction correction requires that the correction represent the value of friction actually affecting the particular test considered. The total losses of a free swing without specimen are not present in an actual test in which the motions of pendulum and recorder are over smaller ranges. Proper proportionate corrections shall always be made unless the difference is not significant in terms of the required accuracy of the test.

(*b*) When the operation of the recorder is not over the full swing of the pendulum and it is necessary to determine the losses of recorder and pendulum separately for accurate friction and windage loss correction this may be done as follows:

> (*1*) Operate the machine in the standard manner, but without a specimen. The value of energy absorbed thus indicated is the total loss in pendulum and indicator combined.
>
> (*2*) Repeatedly release the pendulum from the initial position without resetting the indicator. The energy loss finally shown is that due to the pendulum alone.
>
> (*3*) The loss of the indicator alone is then approximately the difference between the values obtained as described in (*1*) and (*2*) above.

(*c*) The two values obtained in Paragraph (*b*) may with sufficient accuracy be assumed to be distributed uniformly over their respective full ranges of action. The net correction for each test will, therefore, be that portion of the total represented by the ratio of the actual range of action in the test to the full range of action of the two retarding forces in the swings without specimen.

Center of Percussion

23. The principles of correct design indicate that energy losses in deformation and vibration are reduced if the dimensions of the pendulum are such that the blow is delivered in such relation to the distributed mass that no force is transmitted to the point of rotation. The point of impact for which this condition obtains is the center of percussion which may practically be defined as the point in a rotating body at which the dynamic mass may be considered concentrated. The center of percussion is located at a distance from the center of rotation equal to the length of a simple pendulum of the same period.

Determination of Center of Percussion

24. (*a*) The location of the center of percussion may be determined experimentally in an actual machine from the expression:

$$l = 0.81\ P^2$$

where l = the distance from the axis to the center of percussion, and
P = the time in seconds of a complete swing (to and fro).

(*b*) In determining P the pendulum shall be allowed to swing only through a small angle not over 10 to 15 deg. The time for a considerable number of swings shall be determined and the average value calculated.

NOTE.—A machine of strong construction may give satisfactory results with a considerable variation from the correct condition but in general it is considered desirable that the center of percussion be as close as possible to the striking edge. The center of percussion may be lowered or raised by the addition of weight below or above the striking edge, respectively. Such changes require considerable care and will change the capacity and calibration of the machine. They should not be made unnecessarily or without careful study.

Striking Velocity

25. The determination of the striking velocity of the machine, neglecting friction, may be made by means of the following expression which is derived from the general laws of motion applying to rigid, rotating bodies:

$$V = \sqrt{2\ gh}$$

where V = the striking velocity in feet per second;
g = the acceleration of gravity in feet per second per sound; and
h = the initial elevation of the center of percussion in feet (or with sufficient accuracy in most machines, the elevation of the center of the striking edge).

INSPECTION AND PRECAUTIONS

General Inspection and Precautions

26. Calibration also will require check and adjustment, if necessary, of the various mechanical dimensions specified in the particular method of test and other general precautions such as the following:

(*a*) With the striking edge in line with the center of gravity and the center of rotation as described in Sections 17 and 18, the striking edge should just touch the specimen when the pendulum is hanging at the position of rest and the machine is level. Any corrections necessary shall be made in the position of the specimen or in the position of the bearing supports for the pendulum.

(*b*) The specimen shall be so supported that at the instant of impact the striking edge strikes flat and across the face of the specimen in the Izod type test and at the center point of the specimen in the Charpy test.

(*c*) The release mechanism shall not bind or exert any accelerating, retarding or vibrational forces during the initial motion of the pendulum.

(*d*) In machines equipped with brakes to prevent free return of the pendulum after breaking a specimen, free swings shall be made with the brake device both inoperative and operative and the effect, if any, observed on the reading. Any significant difference in reading shall be eliminated.

(*e*) Careful measurements shall be made to establish agreement with the dimensional requirements of Sections 6 and 7.

APPENDIX

A1. *Applications of the Impact Test.*—The basic assumption of the impact test is that resistance to shock depends upon the ability of material rapidly and safely to equalize concentrated stresses.

A2. It is an essential feature of the test that the initial stress be highly localized by the notch and by the rapidity of the blow. Unavoidably, therefore, the intensity and distribution of stress during the break do not yield to analysis in terms of the dimensions of the test piece and method of load application as they depend upon the characteristics of the particular material. The results, therefore, are stated only in terms of the total energy required to break a standard specimen under established conditions. Interpretation of results must be based upon specific research or upon the established limitations of the test.

A3. *Relation to Service Conditions.*—A large part of the total energy indicated as impact strength is expended in deforming the material tested beyond the elastic limit and causing complete fracture. The comparison of materials by this test is, therefore, based to a large extent upon this part of their properties. Such a comparison would have little meaning in parts so carefully designed or so fortunately situated as never to be stressed above the elastic limit at any point.

A4. In present engineering practice there are many parts which by reason of their functioning must be of intricate shape with drastic changes in cross section. When such parts are subject to sudden or impact loading, concentrated stresses of high and generally unpredictable magnitude occur in the region of the change of section. It is to materials for such uses that the impact test applies and the indications of the test are well established as a criterion of satisfactory service use in a large number of specific applications.

A5. Correlation between service failure and low impact strength values for heat-treated forgings has been definitely established in a considerable number of critical uses. The formal specification of impact strength limits based on experience is established practice of representative manufacturers in the following instances:

(*a*) Aviation engine parts such as connecting rods, pins, gears, cylinder retaining loops;
(*b*) Crankshafts for important uses such as aviation engines, industrial engines, truck and tractor engines;
(*c*) Alloy-steel forgings for gun parts, propeller shafts, live axles, etc.;
(*d*) Clash gears for automotive transmissions, particularly for heavy duty uses such as trucks and tractors;
(*e*) Turbine blading;
(*f*) Links, pins, etc., for tractor belts;
(*g*) Wood parts for airplane construction; and
(*h*) Molded parts for telephone apparatus.

A6. *Comparison of Materials.*—The indications of the impact test are more significant in the comparison of generally similar materials such as different classes of steel or steel from different sources than in the comparison of materials of widely different types such as soft copper and hardened steel. It is most significant as an indication of the effect of different variations or treatments of the same material, such as cold working or heat treatment.

A7. In heat treatment of steel (particularly alloy steels such as chrome-nickel) it gives comparisons of temper brittleness not shown by static tests and is invaluable in developing the best heat treatment for a particular steel.

A8. The indications of the impact test can be applied to the development and control of steel through its original production to the development of particular properties after a given heat treatment.

A9. The impact is of great value in the detection and control of abuses in the forge shop such as excessive temperatures and improper response to heat treatment.

A10. Similarly, the detection of deficiencies in process by this type of test are established in the case of materials such as porcelain and crockery and in organic molded materials.

TENTATIVE METHOD OF ANALYSIS FOR THE PARTICLE SIZE DISTRIBUTION OF SUB-SIEVE SIZE PARTICULATE SUBSTANCES[1]

A.S.T.M. Designation: E 20 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1933.

Scope

1. This method is intended for determining the particle size of particulate substances in absolute units, as far as the particle shape will permit.

(*a*) The method applies in its entirety to homogeneous materials. In the case of mixtures, the extent of application is limited by the properties of the components of the mixture.

(*b*) The method applies to the range of sizes between the 74-micron (No. 200) sieve and 0.2 micron.

DEFINITIONS

Definitions

2. (*a*) *Dispersion.*—In statistical work it is measured by the standard deviation. In microscopy it refers to the distribution of the individual particles. Both uses of the word seem too generally accepted to warrant a change in either.

(*b*) *Individual Particle.*—Those minute units of matter (of which the material is composed) whose size and shape depend only on the force of cohesion. Such particles cannot be subdivided without separating like molecules that are within the range of the cohesive attraction of one another.[2]

(*c*) *Aggregate.*—A group of two or more attached particles.

NOTE.—There are three forms of aggregates: namely, ultimate working unit, flocculate, and apparent flocculate.

(*d*) *Ultimate Working Unit.*—An individual particle or any group of individual particles that are so firmly held together by forces of adhesion that they remain intact as a group throughout the duration of their application.

(*e*) *Flocculate.*—Flocculation occurs only where particles have been incorporated in a liquid or plastic medium. A flocculate is a group of particles held together by a force, apparently arising from interfacial tension. This force of flocculation is relatively weak, consequently flocculates do not function as large individual particles, and cannot be classified under ultimate working units. Under slight continuously applied force flocculates are constantly breaking down and reforming.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. L. T. Work, Chairman of the Technical Committee on Particle Size and Shape, of Committee E-1 on Methods of Testing, Havemeyer Hall, Columbia University, New York City.

[2] Henry Green, *Journal of Industrial Hygiene,* Vol. 7, p. 155 (1925).

Apparent flocculates as found in gas-floated or air-floated particles show a somewhat similar type of aggregation. Usually the force of attraction between the particles is relatively weak and the particles can readily be dispersed in suitable media. For practical purposes, the more inclusive term, aggregate, is preferable to flocculate for gas-floated or air-floated particles.

(*f*) *Average Diameter.*—The diameter of a hypothetical particle which, in some particular way, represents the total mass of particles.

(*g*) *Non-uniformity.*—A non-uniform particulate substance is one in which the constituent particles differ from one another in diameters.

Results—Average Diameters

3. Results shall be expressed using one or more of the following average diameters:

AVERAGE DIAMETER	TO BE USED:	FORMULA
$\bar{d}_1$	As arithmetical mean	$d_1 = \frac{\Sigma nd}{\Sigma n}$
$\bar{d}_3$	To determine S when ρ is known	$d_3 = \frac{\Sigma nd^3}{\Sigma nd^2}$
$\bar{d}_4$	To determine volume or weight distribution	$d_4 = \frac{\Sigma nd^4}{\Sigma nd^3}$
$\bar{D}$	To determine N when ρ is known	$D = \sqrt[3]{\frac{\Sigma nd^3}{\Sigma n}}$
Δ	To determine S when N is known	$\Delta = \sqrt{\frac{\Sigma nd^2}{\Sigma n}}$
M_g	As geometric mean or median	$\log M_g = \frac{\Sigma n \log d}{\Sigma n}$

SYMBOLS

S_m = specific surface in square meters per gram
S_v = specific surface in square meters per cubic centimeter
N_m = number of particles per gram
N_v = number of particles per cubic centimeter
Σn = number of particles in any given mass
ρ = density of the material
θ = arithmetic standard deviation
θ_g = geometric standard deviation
P.E. = probable error

PROCEDURE

Rough Separation into Size Groups

4. (*a*) For pigments or other materials which are essentially less than 6 microns proceed directly with the preparation of the mount.

(*b*) For wide ranges of distribution of particle size in sub-sieve size portions, auxiliary separation into groups of sizes is necessary to facilitate measurement with the microscope. Rough separation is permissible as exact size measurement in microns follows. The following general ranges of particle diameter are proposed for the separation:

A	Down to 24 microns
B	24 to 12 microns
C	12 to 6 microns
D	6 to 0.2 microns

For specific purposes A or D may be further separated.

NOTE.—If the sample contains particles larger than the 74-micron (No. 200) sieve, the material shall be separated by sieving wet in a suitable fluid. The portion which passes the sieve may be recovered by evaporation of the fluid. The portion which remains on the sieve may be subjected when dry to a standard sieve test and additional material that passes the 74-micron (No. 200) sieve added to that which is to be tested.

(*c*) Separation shall be made by air or liquid elutriation or by sedimentation at room temperature. The volume of liquid in the elutriator or sedimentation apparatus should be between 20 and 100 ml. per gram of solid. With finer particles and with material of lesser density the greater volumes should be used. The technique involved in the elutriation or settling is necessarily influenced by the type of material being measured and the dispersing liquids. The size of the vessel and dispersion will be specified in terms of the uniformity obtained. The microscope measurement will be used as a check upon the effectiveness of the separation. For accurate results at least 50 per cent by weight must fall within the boundaries of the suggested ranges set for the elutriation. Of the material falling outside the boundaries not over 5 per cent by weight may fall outside of a range which is one half of the lower limit and twice the upper limit of the range under consideration.

(*d*) The fluid used in the elutriation or sedimentation shall contain no dissolved solids which would influence the weight determination of a given portion, that is, the fluid shall be 100 per cent volatile. It shall not react chemically with the material being elutriated. Water, kerosine, alcohols, and the like may be used. It is suggested that the filtering of any elutriator portion should be through alundum to avoid contamination of the sample with paper or pulp fibers. As an alternative, the solid may be recovered from each stage of the elutriator by evaporation of a concentrated slurry, providing the temperatures used for the evaporation do not alter the specific product. The total weight of the portions recovered shall check within 5 per cent the weight of material initially placed in the elutriator.

(*e*) All limits are specified to insure good microscopic technique. Good elutriation technique for analytical purposes falls well within these limits.

NOTE.—Quite obviously, materials containing components of different densities will elutriate or settle in ranges of low uniformity. The present requirements can only be applied when the material meets the following requirements for homogeneity. If the materials can be readily identified under the microscope, they may be measured individually and the results considered as exact, notwithstanding wide differences in density between two materials which may cause lack of uniformity. In other cases, such as cement or coal, where the presence respectively of gypsum and ash constituents may affect the test, these effects may be considered negligible for the normal type of products.

Preparation of the Mount

5. Any one of a number of methods of preparing the mount may be used, the criterion of suitability being conformity to the following requirements:

The particles shall be essentially in one plane.
The particles shall be free from motion.
The particles shall be dispersed, showing individual grains instead of aggregates and flocculates.
The particles shall not be ground in mounting.
The mount shall be truly representative of the distribution of sizes in the material.
The mounting medium shall be selected to give maximum definition.

(*a*) *Fine Materials, Pigments, etc.*—The type of mount that should be used depends on the physical properties of the particles, and for this reason no definite requirements are specified. The general procedure shall be to place the material being tested on a microscope slide, rub it out in a solution of gum or resin in a solvent until the particles are well dispersed. After the solvent has evaporated, the non-volatile constituent of the dispersing agent serves to cement the particles to the slide in the dispersed state.

NOTE.—Detailed technique will be found in the work of Dunn[1] and Green.[2] The former uses balsam in xylol, and the latter turpentine and dammar. Other mounting media suggested are 0.5 per cent glycerine in alcohol, rubber cement, styrax in xylol, and the chlorinated naphthalenes and saponin.

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[1] E. J. Dunn, Jr., *Industrial and Engineering Chemistry*, Analytical Edition, Vol. 2, p. 15 (1930).

[2] Henry Green, *Industrial and Engineering Chemistry*, Vol. 16, No. 7, p. 667 (1924).

(*b*) *Coarse Material, Ground Products, etc.*—In the case of coarse materials it is often advantageous to use the so-called dry mount, in which the dispersing agent used is volatile and can be driven off after the material has been dispersed on the slide. The uniformity of the mount when examined microscopically is the best criterion of an acceptable mount.

METHODS OF MEASUREMENT

Direct Observation Method

6. Direct observations using the Filar micrometer.[1] This type of measurement has been used with fair success and reasonable degree of accuracy on the coarser fraction of particulate substances. The Filar micrometer is an instrument that fits over the ocular of the microscope and permits direct measurement of the particle as viewed on the slide. This method, however, is not recommended for materials in the 0.2 to 6 micron class size.

Projection Method

7. The projection method[2] which involves throwing the image of the particle on a screen has several distinct advantages. It further magnifies the image, permits focusing through the depth of the mount insuring a proper focus and count of all the particles.

Photomicrographic Method

8. The photomicrographic method[3,4] which involves taking a photomicrograph of the particles and subsequently measuring them on a print or by projecting the negative on the screen is also recommended. This method has the very decided advantage of making a permanent record of the sample and permits eye comparisons of two or more samples. In the use of this method it is extremely important that the mount be made according to the method outlined under the method of Green[3] and fulfill the requirements specified there.

Measurement of Diameter

9. In each of the three methods referred to in Sections 6, 7 and 8, the horizontal diameter shall be measured, unless the particles are very uniform in shape and in that event a diameter which most nearly represents the average shall be selected. For irregularly shaped particles the horizontal diameter splitting the particle in half in one direction consistently maintained has been shown[5] to

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[1] Weigel, U. S. Bureau of Mines *Technical Paper No. 296* (1922).

[2] E. J. Dunn, Jr., *Industrial and Engineering Chemistry*, Analytical Edition, Vol. 2, p. 15 (1930).

[3] Henry Green, *Journal*, Franklin Inst., Vol. 192, p. 637 (1921).

[4] Sheppard and Lambert—not yet published.

[5] Martin, *Journal*, Am. Ceramic Soc., Vol. 23, p. 61 (1924).

give fairly consistent and accurate results. For flat plates it is necessary to consider the third dimension for accurate results. In any case, in reporting results, the diameter measured shall be specified.

Scale Limits for Measurement

10. (*a*) If more than 10 per cent by weight is coarser than 6.00 microns, the sample shall be elutriated prior to microscopic measurement. A graded scale for microscopic sizing is given below:

Diameter Range in Microns

General Case (20 per cent or more under 6 microns)	Special Case (Less than 20 per cent under 6 microns)
72 to 60	
60 to 48	
48 to 36	
36 to 24	
24 to 18	
18 to 12	
12 to 9	
9 to 6	
	Same Scale and
6.00 to 5.00	6 to 4.5
5.00 to 4.00	4.5 to 3
4.0 to 3.5	3 to 1.5
3.5 to 3.0	1.5 to 0
3.0 to 2.5	
2.5 to 2.0	
2.0 to 1.8	
1.8 to 1.6	
1.6 to 1.4	
1.4 to 1.2	
1.2 to 1.0	
1.0 to 0.9	
0.9 to 0.8	
0.8 to 0.7	
0.7 to 0.6	
0.6 to 0.5	
0.5 to 0.4	
0.4 to 0.3	
0.3 to 0.2	
0.2	

(*b*) Two hundred and fifty particles shall be measured in each of three fields, taken at random.

(*c*) The magnification shall be dependent on the class size being measured, and shall be sufficient to permit the differentiation specified above.

Expression of Results

11. (*a*) If 90 per cent by weight fall in any one class size, a frequency curve shall be given.

(*b*) In the 0 to 6-micron class either a frequency curve or the distribution by weight shall be given.

(*c*) In elutriated products, weight distribution shall be expressed as follows:

Weight distribution shall be the basis of comparison for all elutriated samples. The weight distribution for each elutriated portion shall be calculated on the basis of spherical particles using the arithmetic mean of the microscopic class interval as the average diameter for all particles in that range. Each of the elutriated fractions shall total in weight distribution to the percentage retained in the elutriator and the composite curve shall be a summation of the distribution values in each range. The degree of overlapping is a measure of the efficiency of the elutriation and it shall not be abnormal in amount.

TENTATIVE METHOD OF TEST

FOR

SHORT-TIME HIGH-TEMPERATURE TENSION TESTS OF METALLIC MATERIALS[1]

A.S.T.M. Designation: E 21 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1933.

Scope

1. This method covers short-time high-temperature tension tests of metals within the range from room temperature to 2000 F. In the interests of coordination of data, it is recommended that the tests be made, as far as possible, at the following temperatures: 70, 300, 500, 750, 900, 1000, 1100, 1200, 1400, 1600, 1800 and 2000 F. It is recognized that for special purposes, tests at other temperatures may be desirable.

Selection of Metals for Test

2. This method presupposes agreement upon the selection of suitable samples for test specimens to meet the requirements of individual applications.

Test Specimens

3. The tension test specimen shall be of the usual type for 2-in. gage length, see Fig. 1, as described in Section 15 of the Standard Methods of Tension Testing of Metallic Materials (A.S.T.M. Designation: E 8) of the American Society for Testing Materials.[2] The diameter of the test specimen shall be 0.505 in. ± 0.001 in. The diameter of the reduced section of the specimen between base of fillets shall not vary by more than ±0.0005 in. The surface shall be machined smooth and free from tool marks or scratches. It shall be finished by

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. N. L. Mochel, Secretary of the Joint A.S.M.E.-A.S.T.M. Research Committee on Effect of Temperature on the Properties of Metals, Westinghouse Electric and Mfg. Co., Lester Station, Philadelphia, Pa.

Cooperation was given by Committee B-4 on Electrical-Heating, Electrical-Resistance and Electric-Furnace Alloys of the American Society for Testing Materials in the preparation of this tentative method of test.

[2] 1933 Book of A.S.T.M. Standards, Part I, p. 949.

polishing with No. 00 emery cloth. The ends of the test specimen shall be threaded, shall be at least $\frac{3}{4}$ in. in diameter, and shall be machined true and axial. They shall be gripped in the testing machine in such manner that the load shall be axially applied.

Testing Apparatus

4. (*a*) *Testing Machine.*—The type of testing machine to be used in short-time high-temperature tension tests is not specified, but shall be reported with the results of a series of tests. The accuracy of the testing machine shall be within the tolerances specified in the Tentative Methods of Verification of Testing Machines (A.S.T.M. Designation: E 4 - 33 T) of the American Society for Testing Materials.[1]

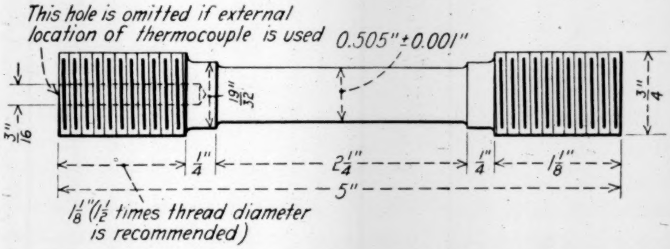
This hole is omitted if external location of thermocouple is used
0.505"±0.001"
19"/32
3"/16
3"/4
1"/4
2 1"/4
1"/4
1 1"/8
5"
1 1"/8 (1 1/2 times thread diameter is recommended)

FIG. 1.—Test Specimen for High-Temperature Tension Tests.

(*b*) *Shackles.*—The type of shackles used to obtain axial loading is not specified, but a detailed description of the shackles used shall be reported with the results of a series of tests.

NOTE.—It is to be noted that eccentricity of loading of the specimen may be lessened by using rods or wire cables of the greatest length possible to connect the shackles to the heads of the testing machine.

Furnace and Heating

5. (*a*) A drawing showing the furnace and heating coil in detail shall be submitted with the results of a series of tests.

(*b*) The furnace shall be heated electrically, and a compensation or gap-wound coil shall be used, the light winding or gap being over the reduced portion of the test specimen. The internal diameter of the furnace shall be as small as possible to allow suitable clearance for the shackles holding the test specimen. The length of the furnace shall be not less than 12 in.

(*c*) The design of the furnace shall be such that the maximum variation of temperature over the gage length of the calibration bar,

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[1] See p. 1013.

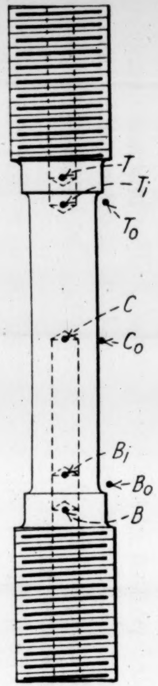

FIG. 2.

Location of Thermocouples

T *Inside top end beyond fillet*
T_i *Inside top end at or within fillet*
T_o *Outside top end at fillet*
C *Inside at center of length*
C_o *Outside at center of length*
B *Inside bottom end beyond fillet*
B_i *Inside bottom end at or within fillet*
B_o *Outside bottom end at fillet*

	Nominal Test Temperature, deg. Fahr.									
T										
T_i										
T_o										
C										
C_o										
B										
B_i										
B_o										

FORM I.—Form for Reporting Temperature Survey of Furnace.

The above form on letter size sheets suitable for recording test data is available in pads of 25 sheets at 50 cents per pad; 3 pads, $1.00. Address, American Society for Testing Materials, 260 S. Broad St., Philadelphia, Pa.

shown in Fig. 2 (see Form I), will not exceed 10 F. for temperatures up to and including 1600 F. and will not exceed 20 F. for higher temperatures.

NOTE.—It may be noted that equalization of temperature over the length of the test specimen may be improved by a metallic lining inside the furnace tube, or by the use of multiple heating coils.

Temperature Measuring Apparatus

6. (*a*) Temperature measurements shall be made by means of suitable thermocouples and potentiometer or millivoltmeter equipment, which shall be accurate to within the following permissible variations for the temperature ranges shown:

	PERMISSIBLE VARIATIONS
Up to and including 1200 F.	± 3 F.
Over 1200 to and including 1600 F.	± 5 F.
Over 1600 F.	± 10 F.

(*b*) The hot junction of the thermocouple shall be located at any one of locations T, T_o, C_o, B_o, B shown in Fig. 2, and the location of the junction shall be reported with the results of tests. Where external contact is made between thermocouple bead and the specimen, the thermocouple shall be shielded in like manner in the tension tests and in the calibration.

Temperature Survey of Furnace

7. (*a*) A survey of the temperature distribution throughout the test specimens shall be made before making a series of tests of specimens of a given metal, on each furnace and test shackle arrangement used. This survey shall be made using a special calibration bar, shown in Fig. 2 (Form I), and for each series of tests the calibration bar used shall be of the same dimensions and shall be of the same type chemical composition as the test specimens to be used. A survey of temperature distribution shall be made for each temperature at which specimens shall be tested, and detailed results of these surveys are to be reported with the results of specimen tests. These surveys furnish data for the comparison of specimen temperature at the point where the thermocouple is applied in routine tests of specimens with the temperature of the test specimen at the middle of the reduced section of the test specimen on the axis of the specimen (C, Fig. 2). The temperature of the calibration bar shall be also determined at the other points indicated in Fig. 2.

(*b*) During a survey of temperature distribution on a calibration, all temperature readings shall be taken as nearly simultaneously as possible.

Room Temperature During Test

8. During the period of time required for survey tests and tests of specimens of a metal the range of room temperature shall not exceed 10 F. During all tests the equipment shall be shielded from abnormal drafts.

Temperature Equilibrium

9. Both in survey tests and tests of specimens to fracture great care shall be taken, after heating to the desired temperature, to be assured that thermal equilibrium has been reached before temperatures are recorded or load and strain readings are taken. In no case shall this heating period be less than 1 hr. The current used in heating the specimen up to the desired temperature shall be approximately that required to hold it at that temperature.

Strain Measurement During Test

10. The details of the extensometer used for strain measurements are not specified, but they shall be reported with the results of tests. The extensometer shall read directly to 0.0002 in. or less for a 2-in. specimen. The extensometer may be attached to the rods or the ends of the shackles projecting beyond the furnace, or optical methods of measurement may be employed.

Test Procedure

11. (*a*) After thermal equilibrium has been established at the temperature desired for the test of a specimen, a series of load and extensometer readings shall be taken under increasing load until the yield strength has been passed.

(*b*) During the part of the test in which the extensometer is in place the speed of head of the testing machine shall in no case exceed 0.1 in. per minute, and, during the period when readings of load and stretch are being taken, the head of the testing machine shall be stopped or its speed so reduced that simultaneous load and extensometer readings may be taken accurately. Within the range of stretch up to the yield strength, at least ten increments of load (or stretch) shall be taken, and as many more as may be necessary to obtain sufficient data for plotting the points for a good stress-strain diagram. If possible, the speed of head should be so regulated as to require about 10 seconds to apply an increment of load (or stretch). If it is found necessary to stop the motion of the head of the testing machine while taking load and extensometer readings, such readings shall be taken as rapidly as is consistent with accuracy. The time consumed in taking the readings shall be reported with the results.

(*c*) After the yield strength has been passed, the extensometer shall be removed and the test continued to rupture, noting the maximum load carried by the specimen. The speed of the head of the testing machine during this period shall be at a rate of not less than 0.22 nor more than 0.28 in. per minute. After the specimen has ruptured, the elongation in the 2-in. gage length and the reduced diameter at rupture shall be measured as described in Sections 29 and 30 of the Standard Methods of Tension Testing of Metallic Materials (A.S.T.M. Designation: E 8) of the American Society for Testing Materials.[1] The location and description of the fracture shall be noted.

Calculation of Stress and Strain

12. For any given test load the stress shall be determined by dividing the maximum load by the area of original cross-section of the test specimen. The strain shall be determined by dividing the elongation in the gage length by the original gage length of the specimen.

Recording and Reporting Data

13. A uniform system of recording and reporting of data shall be used. The accompanying forms for recording and reporting shall be used so that results from cooperating laboratories may be readily compared.

(*a*) *Reporting Temperature Surveys.*—For reporting the results of the temperature distribution surveys, Form I is recommended.

(*b*) *Stress-Strain Diagrams.*—Stress-strain diagrams of all tests of specimens shall be included in the report. For plotting stress-strain diagrams[2] of tests the following scales are recommended:

YIELD STRENGTH VALUES, LB. PER SQ. IN.	SCALE FOR STRESS (ORDINATES)	SCALE FOR STRAIN (ABSCISSAS)
70 000 to 140 000	1 in. = 20 000 lb. per sq. in.	1 in. = 0.002 in. per in.
35 000 to 70 000	1 in. = 10 000 lb. per sq. in.	1 in. = 0.001 in. per in.
Below 35 000	1 in. = 5 000 lb. per sq. in.	1 in. = 0.0005 in. per in.

The *yield strength* for each specimen tested shall be determined from its stress-strain diagram. Yield strength is defined as the stress at which a material exhibits a specified limiting permanent set. For short-time high-temperature tension tests of iron, steel and the stronger non-ferrous metals the specified limiting permanent set shall be taken as 0.2 per cent of the gage length of the specimen, and the "set method" of determining yield strength, as described in Section 26 of the Standard Methods of Tension Testing of Metallic Materials (A.S.T.M. Designation: E 8) of the American Society for Testing Materials[1] shall be used.

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[1] 1933 Book of A.S.T.M. Standards, Part I, p. 949.

[2] Dietzgen No. 340–10 or equivalent cross-section paper is recommended for this purpose.

FORM II.—FORM FOR REPORTING DATA AND RESULTS OF SHORT-TIME HIGH-TEMPERATURE TENSION TESTS.[1]

Material.. From..

Testing Machine.................................. Extensometer..................................

Date.. Test Laboratory...............................

1. RESULTS OF TEMPERATURE DISTRIBUTION SURVEY						
Specimen................................						
Nominal test temperature, deg. Fahr........						
Inside temperature, end of specimen beyond fillet, deg. Fahr..........................						
Inside temperature center of length of specimen, deg. Fahr.						
2. OBSERVED DATA OF SHORT-TIME HIGH-TEMPERATURE TENSION TESTS						
Speed of head of testing machine up to removal of extensometer, in. per minute.....						
Speed of head of testing machine after removal of extensometer, in. per minute.....						
Original diameter of specimen, in...........						
Reduced diameter of specimen, in..........						
Maximum load, lb..........................						
Elongation in 2 in., in.....................						
Type of fracture..........................						
Location of fracture.......................						
3. CALCULATED RESULTS OF SHORT-TIME HIGH-TEMPERATURE TENSION TESTS						
Tensile strength, lb. per sq. in..............						
Yield strength (0.2 per cent of set), lb. per sq. in....................................						
Elongation in 2 in., per cent................						
Reduction of area, per cent.................						

[1] The above form on letter size sheets suitable for recording test data is available in pads of 25 sheets at 50 cents per pad; 3 pads, $1.00. Address, American Society for Testing Materials, 260 S. Broad St., Philadelphia, Pa.

(c) *Reporting Test Data.*—For reporting the data and results of short-time high-temperature tension tests Form II is recommended.

(d) *Plotting Test Data.*—For showing the general results of a series of short-time high-temperature tension tests a set of graphs[2] is recommended, in which temperature values are plotted as abscissas and values of (*1*) tensile strength, (*2*) yield strength, (*3*) elongation in 2 in., and (*4*) reduction of area are plotted as ordinates. For steel and the stronger non-ferrous metals the following scales for plotting are recommended:

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[1] 1933 Book of A.S.T.M. Standards, Part I, p. 949.

[2] Dietzgen No. 340–10 or equivalent cross-section paper is recommended for this purpose.

		Tension Test Scale (Ordinates)	Temperature Scale (Abscissas)
Tensile strength and Yield strength	Max. tensile strength not over 100,000 lb. per sq. in..........	1 in. = 10,000 lb. per sq. in.	1 in. = 200 F.
	Max. tensile strength over 100,000 lb. per sq. in............	1 in. = 20,000 lb. per sq. in.	1 in. = 200 F.
Elongation and Reduction of area	....	1 in. = 10 per cent	1 in. = 200 F.

(*e*) *Summary of Data.*—In reporting results of short-time high-temperature tension tests full information about material, apparatus and test methods shall be reported, as follows:

Materials.—The report shall include the following information concerning the materials tested:

Process of manufacture and whether material is rolled, forged or cast.

Complete chemical analysis.

Complete details of heat treatment.

Physical properties of the material at room temperature.

Size of sample from which specimens were cut.

Relative location and direction of specimen. (Illustrate with sketch.)

If material was removed from service, complete details of service conditions shall be given.

Microstructure and deep etch of samples.

Test Methods.—The report shall include the following information concerning the apparatus and methods of testing:

Description of apparatus, shackles used, method of calibrating loading mechanism and accuracy of loading.

Description of temperature control-recording arrangement.

Description of furnace.

Description of elongation measuring device.

Radical departures, if any, from recommended procedure and technique.

Results of temperature surveys of furnace, Form I (see Paragraph (*a*)).

Stress-strain diagrams (see Paragraph (*b*)).

Test data required on Form II (see Paragraph (*c*)).

Curves showing relation of physical properties to temperatures (see Paragraph (*d*)).

TENTATIVE METHOD OF TEST
FOR
LONG-TIME (CREEP) HIGH-TEMPERATURE TENSION TESTS OF METALLIC MATERIALS[1]

A.S.T.M. Designation: E 22 – 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1933.

Scope

1. (*a*) This method covers long-time (creep) high-temperature tension tests of metals within the range from room temperature to 2000 F.

(*b*) Long-time tension tests shall be made at those elevated temperatures where creep effects assume technical or engineering importance. The range of temperature that should be investigated for some of the important classes of metals are as follows:

	TEMPERATURE RANGE, DEG. FAHR.
Carbon steels	550 to 1100
Low alloy steels (less than 8 per cent alloy content)	550 to 1200
High alloy steels (non-austenitic)	750 to 1400
High alloy steels (austenitic[a] and semi-austenitic)	750 to 1800
Nickel-chromium and high nickel-chromium-iron alloys	900 to 2000
Copper and aluminum alloys	300 to 800

[a] Under austenitic alloys are included those alloys wholly austenitic, austenitic-ferritic, and those which may change from originally an austenitic structure to some other conditions not definitel known.

(*c*) Testing temperatures shall in all cases be established only at points that are multiples of 50 on the Fahrenheit scale.

(*d*) Tests undertaken for the purpose of locating limiting service temperatures or critical temperatures, shall be made at each 50 F. interval on the narrowest range in which the limiting or critical temperature is shown to exist by previous investigations.

Selection of Metals for Test

2. This method presupposes agreement upon the selection of suitable samples for test specimens to meet the requirements of individual applications.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. N. L. Mochel, Secretary of the Joint A.S.M.E.–A.S.T.M. Research Committee on Effect of Temperature on the Properties of Metals, Westinghouse Electric and Mfg. Co., Lester Station, Philadelphia, Pa.

Test Specimens

3. Test specimens, wherever possible, shall be of the usual type for 2-in. gage length, see Fig. 1, as described in Section 15 of the Standard Methods of Tension Testing of Metallic Materials (A.S.T.M. Designation: E 8) of the American Society for Testing Materials.[1] The diameter of the test specimen shall preferably be 0.505 in. ± 0.001 in. In cases where small diameter is imperative, specimens having a diameter of either 0.357 in. or 0.252 in. may be used, but the gage length shall be not less than 2 in. The diameter of the reduced section of the specimen between base of fillets shall not vary by more than ± 0.0005 in.

The surface shall be machined smooth and free from tool marks or scratches. It shall be finished by polishing with No. 00 emery cloth. The ends of the test specimen shall be threaded, at least $\frac{3}{4}$ in. in diameter for the 0.505-in. specimen, $\frac{1}{2}$ in. in diameter for the 0.357-in. specimen, and $\frac{3}{8}$ in. in diameter for the 0.252-in. specimen, and shall be machined true and axial. A sketch showing the type of specimen used shall accompany the report of test results.

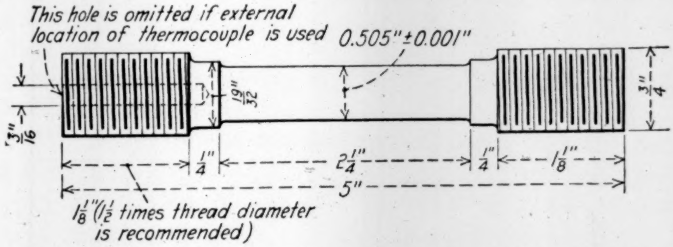
This hole is omitted if external location of thermocouple is used
0.505"±0.001"
3"/16
19"/32
3"/4
1"/4
2 1/4"
1"/4
1 1/8"
5"
1 1/8" (1 1/2 times thread diameter is recommended)

FIG. 1.—Test Specimen for High-Temperature Tension Tests.

Testing Machine

4. (*a*) The type of testing machine to be used in long-time (creep) high-temperature tests is not specified, but shall be reported with the results of a series of tests. The applied load shall be calibrated to an accuracy within ±1 per cent. Precaution shall be taken to avoid excessive inertial and frictional effects in the loading mechanism.

(*b*) Precautions shall be taken to insure that the testing load is axially applied. Each specimen when set up for test shall be inspected for faulty alignment in the machine. Eccentricity of loading can often be detected by elastic extension measurements taken at room temperature before commencing the test. Apparatus provided with extensometers affording measurements on opposite

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[1] 1933 Book of A.S.T.M. Standards, Part I, p. 949.

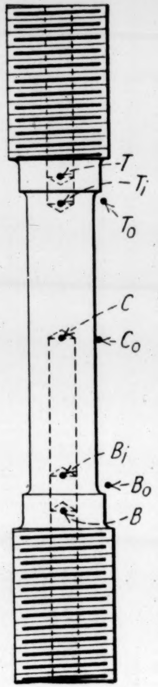

FIG. 2.

Location of Thermocouples

T *Inside top end beyond fillet*
T_i *Inside top end at or within fillet*
T_o *Outside top end at fillet*
C *Inside at center of length*
C_o *Outside at center of length*
B *Inside bottom end beyond fillet*
B_i *Inside bottom end at or within fillet*
B_o *Outside bottom end at fillet*

	Nominal Test Temperature, deg. Fahr.									
T										
T_i										
T_o										
C										
C_o										
B										
B_i										
B_o										

FORM I.—Form for Reporting Temperature Survey of Furnace

The above form on letter size sheets suitable for recording test data is available in pads of 25 sheets at 50 cents per pad; 3 pads, $1.00. Address, American Society for Testing Materials, 260 S. Broad St., Philadelphia, Pa.

sides will reveal unsatisfactory alignment when unequal strain is shown by the opposite readings. Elongation measuring devices which show extension on one side of the specimen only do not readily lend themselves to the detection of eccentric loading.

(*c*) *Shackles.*—The type of shackles used to obtain axial loading are not specified, but a detailed description of the shackles used shall be reported with the results of a series of tests.

NOTE.—It is to be noted that eccentricity of loading of the specimen may be lessened by using rods or wire cables of the greatest length possible to connect the shackles to the heads of the testing machine.

Furnace and Heating

5. (*a*) A drawing showing the furnace and heating coil in detail shall be submitted with the results of a series of tests.

(*b*) The furnace shall be heated electrically and a compensation or gap-wound coil shall be used, the light winding or gap being over the reduced portion of the test specimen. The internal diameter of the furnace shall be as small as possible to allow suitable clearance for the shackles holding the test specimen. The length of the furnace shall be not less than 12 in.

(*c*) The design of the furnace shall be such that the maximum variation of temperature over the gage length of the calibration bar, shown in Fig. 2 (Form No. I) will not exceed 5 F. for temperatures up to and including 1200 F., 10 F. for temperatures over 1200 F. and up to and including 1600 F., and 20 F. for temperatures over 1600 F.

NOTE.—It may be noted that equalization of temperature over the length of the test specimen may be improved by a metallic lining inside the furnace tube, or by the use of multiple heating coils.

Temperature Measuring Apparatus

6. (*a*) Temperature measurements shall be made by means of suitable thermocouples and potentiometer or millivoltmeter equipment, which shall be accurate to within the following permissible variations for the temperature ranges shown:

	PERMISSIBLE VARIATIONS
Up to and including 1200 F.	± 3 F.
Over 1200 to and including 1600 F.	± 5 F.
Over 1600 F.	± 10 F.

(*b*) The hot junction of the thermocouple shall be located at any one of the locations T, T_o, C_o, B_o, B shown in Fig. 2, and the location of the junction shall be reported with the results of tests. Where external contact is made between thermocouple bead and the specimen, the thermocouple shall be shielded in like manner in the creep tests and in the calibration.

Temperature Survey of Furnace

7. (*a*) A survey of the temperature distribution throughout the test specimens shall be made before making a series of tests of specimens of a given metal, on each furnace and test shackle arrangement used. This survey shall be made using a special calibration bar, shown in Fig. 2, and for each series of tests the calibration bar shall be of the same dimensions, and shall be of the same type chemical composition, as the test specimens to be used. A survey of temperature distribution shall be made for each temperature at which specimens are to be tested, and detailed results of these surveys shall be reported with the results of specimen tests. These surveys furnish data for the comparison of specimen temperature at the point where the thermocouple is applied in routine tests of specimens with the temperature of the test specimen at the middle of the reduced section of the test specimen on the axis of the specimen (*C*, Fig. 2). The temperature of the calibration bar shall be also determined at the other points indicated in Fig. 2.

(*b*) During a survey of temperature distribution on a calibration, all temperature readings shall be taken as nearly simultaneously as possible.

(*c*) Testing temperature as normally measured during the course of a test shall be corrected, if necessary, using the survey data as a basis of correction. The amount of correction applied shall be the difference between the temperature as normally measured and that found to be the average shown by the survey couples imbedded at the required points.

Room Temperature During Tests

8. During the period of time required for survey tests the range of room temperature shall not exceed 10 F. During creep tests, the room temperature shall be kept as constant as possible, and all elongation measurements shall be taken when the variation in room temperature does not exceed 10 F. During all tests the equipment shall be shielded from abnormal drafts.

Sustained Loads

9. (*a*) The constant-temperature, constant-stress method shall be employed in creep tests. Stresses to produce creep at the rate of 1.0 per cent per 10,000 hr. and 0.1 per cent per 10,000 hr. in the secondary flow period shall be determined. For some applications it

may be necessary or desirable to determine the stress to produce creep at the rate of 0.01 per cent per 10,000 hr. in the secondary flow period. (See Section 10.)

(*b*) A preliminary exploration shall be made. A number of specimens shall be subjected, at constant temperature, to different stresses in pounds per square inch selected from those in the following list: 250, 500, 750, 1000, 2000, 3000, 5000, 7500, 10,000, 15,000, 20,000, 25,000, 30,000, 40,000, 50,000, 60,000, 70,000 lb. per sq. in., etc. No specimen shall be used for more than one test at the stress and temperature selected. This exploration will provide an estimation of the creep-stress relations, at the selected temperatures.

(*c*) From this estimation, additional tests shall be made on individual specimens at such loads in round hundreds or thousands of pounds per square inch, suitable to the material and temperature, as to achieve the desired object.

Evaluation of Creep Test Results

10. (*a*) Test data shall be evaluated on a basis of the *sensitivity* of elongation measurement afforded by the apparatus employed. By sensitivity shall be understood the smallest interval per unit of gage length to which an elongation determination can be reproduced by successive measurements when no permanent deformation has taken place in the interval between readings.

(*b*) In view of the fact that good sensitivity of elongation measurement and accuracy of creep rate determination are not attainable unless temperature fluctuations are minimized, the following restrictions shall be placed upon the evaluation of tests:

SENSITIVITY OF ELONGATION MEASUREMENT, PARTS PER MILLION OF GAGE LENGTH	PERMISSIBLE TEMPERATURE FLUCTUATION, DEG. FAHR.	SMALLEST RATE OF CREEP REPORTABLE FROM TESTS OVER THE SPECIFIED INTERVAL[a]	MINIMUM TIME PERIOD, HR.
4	1	0.01 per cent per 10 000 hr.	2000
20	2	0.1 per cent per 10 000 hr.	1000
100	5	1.0 per cent per 10 000 hr.	500
500	5	10.0 per cent per 10 000 hr.	250

[a] It should be recognized that all these creep rates are extrapolations.

(*c*) The report shall include information as to the sensitivity, temperature fluctuation, and the actual time yield curves.

Test Procedure

11. The following procedure shall be observed in all tests:

(*a*) It is recommended that not more than one specimen be placed in a furnace at one time, and that each furnace be provided with its own individual control.

(*b*) Before heating, the specimen shall be loaded to check alignment. (See Section 4 (*b*).)

(*c*) During heating to the temperature desired, the test specimen shall not sustain a unit load in excess of 250 lb. per sq. in.

(*d*) The heating period preparatory to loading shall be long enough to establish thermal equilibrium and shall be reported. The load shall then be applied without sudden jolt to specimen.

(*e*) The immediate elongation in gage length upon application of load shall be observed and reported.

(*f*) Further elongation observations shall be made after intervals of 8 hr., 24 hr., 48 hr., and each 24-hr., 48-hr., or other necessary periods thereafter until the completion of the constant-temperature, constant-stress run. Time intervals shall be such that all characteristics of the elongation will be observed.

(*g*) When the testing of a specimen that is not ruptured is to be discontinued, the elastic recovery or contraction of the gage length upon removal of load shall be observed, before allowing the specimen to cool and this shall be reported.

(*h*) All specimens tested shall be carefully preserved for six months for further studies as to their hardness, microstructure, impact resistance, etc., should such be desired.

(*i*) Measurements of gage length shall be made at room temperature before placing the specimen in, and after removing the specimen from the furnace and reported.

Recording and Reporting of Data

12. A uniform system of recording and reporting of data shall be used. The accompanying forms for recording and reporting shall be used so that results from cooperating laboratories may be readily compared.

(*a*) *Reporting Temperature Surveys.*—For reporting the results of the temperature distribution surveys, Form I is recommended.

(*b*) *Reporting Test Data.*—Form II shall be used for reporting the data and results of long-time (creep) high-temperature tests. The data required on Form II are sufficient for completing the time-creep curves and for evaluating creep rates. Under the column "Remarks" shall be noted the increases in stress, temperature fluctuations, etc.

(*c*) *Time-Creep Curves.*—For plotting time-creep curves[1] the following scales shall be used:

SCALE FOR TIME (ABSCISSAS)	SCALE FOR CREEP (ORDINATES)
1 in. = 100 hr.	½ in. = 0.001 in. for creep rates of 1 per cent in 10,000 hr.
1 in. = 100 hr.	½ in. = 0.0001 in. for creep rates of 0.1 per cent in 10,000 hr.

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[1] Dietzgen No. 340–10 or equivalent cross-section paper is recommended for this purpose.

FORM II.—FORM FOR REPORTING DATA AND RESULTS OF LONG-TIME (CREEP) HIGH-TEMPERATURE TENSION TESTS.

Test Laboratory ....

Material .... Specimen No. ....

Test Temperature .... Original Stress ....

Location of thermocouple ....

Sensitivity of elongation measuring device ....

Time allowed for equilibrium before loading ....hr. ....min

Temperature fluctuation of specimen ....deg. Fahr.

Temperature fluctuation of room ....deg. Fahr.

Total elongation, loaded ....in.

Creep rate over test period ....per cent

Creep rate during secondary period ....per cent

Immediate extension upon application of load ....in.

Contraction upon removal of load ....in.

Original gage length, room temperature ....in.

Gage length after test, room temperature ....in.

Change in gage length, room temperature ....in.

ELONGATION

Date	Hours Duration	Total Inches	Inches per Inch	Increment, in. per Inch	Remarks

The above form on letter size sheets suitable for recording test data is available in pads of 25 sheets at 50 cents per pad; 3 pads, $1.00. Address, American Society for Testing Materials, 260 S. Broad St., Philadelphia, Pa.

(*d*) *Stress-Temperature Curves.*—For plotting stress-temperature curves[1] the following scales shall be used:

SCALE FOR TEMPERATURE (ABSCISSAS)	SCALE FOR STRESS (ORDINATES)
½ in. = 100 F.	1 in. = 10,000 lb. per sq. in.

Curves showing creep rates in the secondary flow period of 0.01, 0.1, 1.0 or 10 per cent per 10,000 hr. shall be plotted.

(*e*) *Summary of Data.*—In reporting results of long-time high-temperature tension tests full information about material, apparatus and tests methods shall be reported, as follows:

Materials.—The report shall include the following information concerning the materials tested:

Process of manufacture and whether material is rolled, forged or cast.

Complete chemical analysis.

Complete details of heat treatment.

Physical properties of the material at room temperature.

Size of sample from which specimens were cut.

Relative location and direction of specimen. (Illustrate with sketch.)

If material was removed from service, complete details of service conditions shall be given.

Micro-structure and deep etch of samples.

Test Methods.—The report shall include the following information concerning the apparatus and methods of testing:

Description of apparatus, shackles used, method of calibrating loading mechanism and accuracy of loading.

Description of temperature control-recording arrangement.

Description of furnace.

Description of elongation measuring device.

Radical departures, if any, from recommended procedure and technique.

Sketch of specimen used.

Results of temperature surveys of furnace, Form I (see Paragraph (*a*)).

Test data required on Form II (see Paragraph (*b*)).

Time-creep curves (see Paragraph (*c*)).

Stress-temperature or creep-rate evaluation (see Paragraph (*d*)).

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[1] Dietzgen No. 340–10 or equivalent cross-section paper is recommended for this purpose.

TENTATIVE METHODS OF VERIFICATION
OF
TESTING MACHINES[1]

A.S.T.M. Designation: E 4 - 33 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED AS TENTATIVE 1923; ADOPTED IN AMENDED FORM, 1924;
REVISED, 1927; REISSUED AS TENTATIVE, 1933.

DEFINITIONS

1. (*a*) *Testing Machine.*—A mechanical device for applying a load (force) to a specimen.

NOTE.—Usually the magnitude of the load can be changed at the will of the operator. Many testing machines are arranged to measure the load, but this is not always the case, especially with impact machines and machines for testing ductility.

(*b*) *Error.*—In the case of a testing machine, the value obtained by subtracting the correct value of the quantity measured (usually load) from the indicated value as given by the testing machine.

NOTE.—The error may be positive or negative.

(*c*) *Percentage of Error.*—In the case of a testing machine, the ratio, expressed as a percentage of the error to the correct value of the quantity measured.

(*d*) *Correction.*—In the case of a testing machine, the value obtained by subtracting the indicated value from the correct value of the quantity measured.

NOTE.—The correction has the same magnitude as the error but the opposite sign. It is recommended that, except for special cases, no corrections be used on machines tested and found to have errors within the tolerances given in these methods.

(*e*) *Tolerance.*—In the case of a testing machine, the maximum allowable error in the value of the quantity indicated.

NOTE.—It is convenient to express tolerance in terms of percentage of error. The numerical value of the tolerance for a testing machine is so stated hereafter in these methods.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. H. F. Moore, Chairman of the Technical Committee on Mechanical Testing of Committee E-1 on Methods of Testing, University of Illinois, Urbana, Ill.

These methods are in effect a revision of, and replace the former Standard Methods of Verification of Testing Machines (A.S.T.M. Designation: E 4 - 27), which standard was accordingly discontinued in 1933.

The word "accurate" applied to a testing machine shall be used without numerical values. The word "error" shall be used with numerical values. For example: "An accurate testing machine was used for the investigation"; but "At a load of 30,000 lb. the error of the testing machine was 15 lb." A testing machine is said to be accurate if the indicated load is within the specified tolerance of the actual load.

NOTE.—The *accuracy* of a testing machine should not be confused with *sensitiveness*. For example, a testing machine might be very sensitive, that is, it might indicate quickly and definitely small changes in the load, but, nevertheless, be very inaccurate. On the other hand, the accuracy of the results is, in general, limited by the sensibility.

(*f*) *Loading Range.*—The loading range of a testing machine or of an apparatus for calibrating a testing machine is the range of indicated loads for which the testing machine or the calibrating apparatus gives results within the tolerances specified.

(*g*) *Elastic Calibration Device.*—An elastic calibration device for use in verifying the load readings of a testing machine consists of an elastic member to which loads may be applied combined with a mechanism for indicating the magnitude of deformation under load.

METHODS FOR VERIFYING TESTING MACHINES THAT MEASURE LOAD

Advantages and Limitations of Different Methods

2. Four methods of verifying testing machines are listed in this standard:

(*a*) *Standard Weights.*—Verification by the direct application of standard weights to the weighing mechanism of the testing machine, where practicable, is the most accurate method. Its limitations are (*1*) the small range of load which can be covered, (*2*) the non-portability of any large amount of standard weights, and (*3*) its non-applicability to horizontal testing machines.

(*b*) *Proving Levers.*—Verification by the use of standardized proving levers loaded with standard weights ranks second in accuracy. Its limitations are (*1*) the fact that the range of load possible with proving levers, while greater than with standard weights, is not great enough to cover the capacity range of large testing machines, and (*2*) the inconvenience of transportation of proving levers and standard weights for verifying large testing machines.

(*c*) *Elastic Calibration Device.*—Verification by the use of an elastic calibration device ranks third in accuracy. It is free from the limitations of the methods referred to in Paragraphs (*a*) and (*b*).

(*d*) *Comparison Method.*—Verification by a comparison of the tensile strength of test specimens ("companion specimens") cut from the same piece of metal, is distinctly less accurate than the three methods referred to in Paragraphs (*a*), (*b*) and (*c*), and should be used only when none of the other methods are available. If the results of a verification test by the comparison method fail to agree with the results of a verification test by any of the other three methods, the results given by the comparison method shall be discarded.

Method of Applying Load

3. In the verification of a testing machine the loads shall be applied in ascending order.

NOTE.—For machines in which the load-indicating device is actuated by a Bourdon pressure tube, a hydraulic (or steam-engine) indicator spring, or other device depending on the elastic properties of a material, the tolerances for the *descending* load shall be applied to differences in the indication for the corresponding ascending and descending readings. In such testing machines the test for ascending load shall be applied as rapidly as practicable after the testing machine has remained unloaded for at least 6 hr., and the time of applying the ascending series of loads shall not exceed 30 minutes. The descending load test shall be made after the maximum test load has remained on the machine for 1 hr., and the readings for descending loads shall be taken as rapidly as possible, and in any event the descending load test shall be completed within a period of 20 minutes.

Selection of Test Loads

4. For any loading range, the testing machine shall be verified by at least five test loads (except for testing machines designed to measure only a smaller number of definite loads, such as certain hardness testing machines). The difference between any two successive test loads shall not exceed one third of the difference between the maximum and minimum test loads.

NOTE.—A testing machine may have more than one loading range. For instance, a 100,000-lb. capacity testing machine may have one loading range from 5000 lb. to 40,000 lb. and a second loading range from 55,000 lb. to 100,000 lb. Section 4 requires that the machine must be verified by at least five test loads between 5000 lb. and 40,000 lb. and also that the machine must be verified by at least five test loads between 55,000 lb. and 100,000 lb.

Eccentric Loading

5. For the purpose of determining the loading range of a testing machine all calibration loads shall be applied so that the resultant load shall be as nearly along the axis of the testing machine as is possible.

NOTE.—The effect of eccentric load on the accuracy of a testing machine may be determined by calibration readings taken with proving levers or an elastic calibration device placed so that the resultant load is applied at definite distances from the axis of the machine, and the loading range determined for a series of eccentricities. In the case of testing machines in which the load reading depends on the hydrostatic pressure in a cylinder fitted with a piston the effect of eccentricity of loading is most serious when the piston is at the extreme outward position allowable.

A. Method of Verification by Standard Weights

Method by Standard Weights

6. Standard metal weights of suitable design, finish, and adjustment shall be placed on the weighing platform of the testing machine or upon trays or other supports suspended from the load-measuring mechanism in place of the specimen. The weights shall be applied in increments and removed in the reverse order. They shall be arranged symmetrically with respect to the weighing platform, so that the center of gravity of the load lies in the vertical line through the center of the platform. The applied load and the indicated load shall be recorded for each test load applied, and the error calculated from these data.

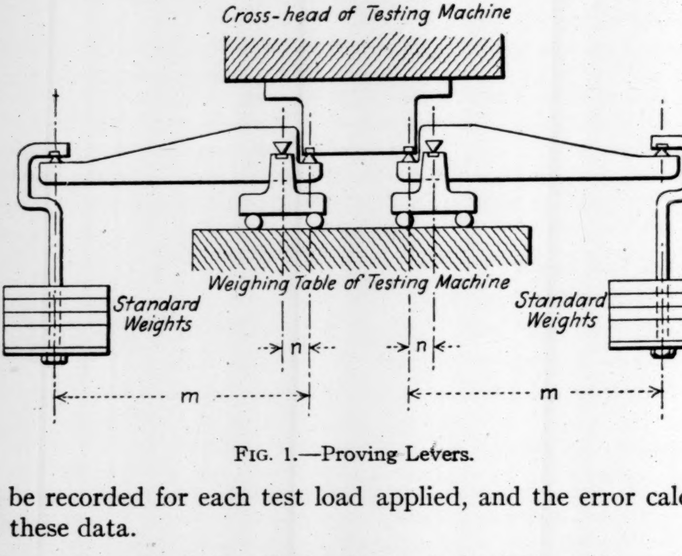
Cross-head of Testing Machine
Weighing Table of Testing Machine
Standard Weights
Standard Weights
n
n
m
m

FIG. 1.—Proving Levers.

NOTE.—The method of verification by standard weights can be used only on vertical testing machines. The total load is limited by the size of the platform and the number of weights available. Often twenty weights of 50 lb. each are used, a total of 1000 lb.

This method of verification is seldom used for any but small testing machines, as the loading range does not include the loads for which large machines are used.

B. Method of Verification by Standardized Proving Levers

Description of Levers

7. The arrangement of proving levers for verifying testing machines is shown in Fig. 1. The two levers rest on supports on the weighing platform of the testing machine. These supports shall move easily in a horizontal direction, which insures that the forces at each of the knife edges shall be very nearly vertical. The inner knife

edges in each lever bear against a suitable block in the movable head of the testing machine. Weight trays or hangers are suspended from each of the outer knife edges and these trays or hangers are loaded with standard weights. The increment of load put on the testing machine by the standard weights is the amount of standard weights multiplied by the lever ratio m/n, Fig. 1.

Specifications of Levers

8. The knife edges, as well as their supports, shall be of hardened tool steel. The knife edges shall be ground sharp to an angle of 90 deg. The load on any knife edge shall not exceed 7000 lb. per linear inch. The three knife edges in each lever shall be parallel, and their edges shall lie in a plane. Each lever shall have machined surfaces in this or in some parallel plane, upon which a spirit level can be placed.

Verification of Levers

9. The lever ratio of a proving lever shall be determined by the use of at least three test loads; the amount of weights used shall not be less than the maximum load applied upon one of the arms of a lever in using the levers to verify testing machines. The proving lever shall be balanced over its center knife edge with suitable weight trays suspended from the end knife edges. Standard weights shall then be applied to the trays in three steps, corresponding approximately to 50, 75, and 100 per cent of the weights available, and the proving lever shall then be brought to a balance by the use of small weights and by observations of the freely swinging proving lever. From the weights in the two weight trays the lever ratio shall be calculated.

Method of Procedure

10. The proving levers shall be placed symmetrically in the testing machine to be verified and both levers brought as near to a horizontal position as is feasible, after applying each increment of load, by means of the movable head of the testing machine. The testing machine shall be balanced with the levers in place and the weight trays empty. Standard weights shall be applied (or removed) in increments, half an increment in (or from) each tray. The weights shall be placed symmetrically on the weight trays, with the center of gravity of the weights over the center of the tray. The applied load and the indicated load shall be recorded for each test load applied, and the error calculated from these data.

NOTE.—The method of verification by standardized proving levers is used, at the present time, only on vertical testing machines. It is often used up to loads of 10,000 lb.

C. Method of Verification by Means of an Elastic Calibration Device[1]

Design and Workmanship

11. An elastic calibration device should be so designed and constructed that its accuracy is not in danger of being impaired by handling, shipping, or ordinary use, and so that parts subject to damage, replacement, or removal for storage and shipment can be replaced without impairing the accuracy of the device.

NOTE.—This section is non-quantitative in its requirements. It is placed in the method for the purpose of calling attention to the fact that an elastic calibrating device if improperly designed and constructed may, like any other delicate measuring instrument, be damaged and rendered inaccurate by handling and shipping.

Shackles and Bearing Blocks

12. An elastic calibration device shall be provided with shackles, bearing blocks, or any other necessary fixtures through which the load is to be applied to the calibration device. All such fixtures should be so designed and constructed that when placed in a testing machine in reasonably good condition there shall be no extra-tolerance variation of reading due to imperfections in the bearing blocks or in the motion of the head of the testing machine.

NOTE.—This section is non-quantitative in its requirements. It is placed in the method for the purpose of calling attention to the fact that poorly designed loading fixtures can render inaccurate the readings of an elastic calibration device.

Graduation of Scale

13. (*a*) The scale of the indicating mechanism shall be uniformly graduated. The distance between any two graduation lines, dots, or other dividing marks shall be not less than 0.04 in. nor more than 0.10 in. The width of the graduation lines, dots, or other dividing marks shall not be more than one fifth of the distance between them. The width of the index line or lines shall not exceed the width of the graduation lines on the scale. This requirement for width of index lines cannot be applied to devices in which the reading is taken from the position of the end of a fluid column along a scale on a glass tube, and this section shall not be interpreted as barring the use of such instruments.

(*b*) The difference between the position of any graduation line and its correct position on the scale shall not exceed one twentieth of the distance between two adjacent graduation lines.

(*c*) For each division of the scale, the change in load required to change the reading from one graduation line to an adjacent graduation line shall not exceed one fifth of 1 per cent of the capacity load.

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[1] The term "calibration device" shall be interpreted to include solid bars, hollow bars, elastic loops, and other members whose elastic deformation can be measured.

Label Showing Manufacturer, Number, and Capacity

14. The manufacturer's name, the capacity load, and the serial number of the device shall be legibly marked on some part of the instrument.

Temperature Equalization

15. When using an elastic calibration device to verify the load readings of a testing machine the device should be placed near, or preferably in, the testing machine a sufficient length of time before the test so that the device and the testing machine shall be at very nearly the same temperature.

Preliminary Cyclic Loading

16. Before taking readings for the formal verification of an elastic calibration device by means of dead weights or other primary standards, the device shall be subjected to a series of cyclic loads varying from a minimum load not greater than 2 per cent of the capacity load of the device to a maximum load not less than 5 per cent nor more than 10 per cent above the nominal capacity load. This cycle of loading shall be repeated until either (*1*) the instrument reading for the corresponding extreme loads of two successive cycles shall not differ by more than one tenth of 1 per cent of the reading for capacity load, or (*2*) it becomes evident that the difference between readings for successive cycles is not diminishing, in which case the device is not to be approved for use in calibrating testing machines.

Elimination of Small Temperature Effects due to Stress

17. To minimize errors due to temperature effects of stress and those due to psuedo-elastic action, the time schedule followed when verifying an elastic calibration device should be reported, especially in the case of an elastic calibration bar which is loaded in axial tension or compression; and approximately the same time schedule should be followed when using the device to calibrate a testing machine.

Primary Standards for Elastic Calibration Devices

18. (*a*) For loads not exceeding 100,000 lb. an elastic calibration device shall itself be calibrated by applying dead weights known to be accurate within 0.02 per cent.

For loads exceeding 100,000 lb. an elastic calibration device may be calibrated by another elastic calibration device or by a combination of several elastic calibration devices, or by proving levers[1] and dead weights. In this case the calibrating load applied shall be known to be accurate within 0.1 per cent.

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[1] The term "proving levers" is not to be interpreted as allowing the use of the lever system of a compound lever testing machine or of a platform scale as a part of a primary standard.

Routine in Calibration of Elastic Calibration Device

19. For any range of test loading which may be applied in calibrating an elastic calibration device there shall be applied at least eight test loads, and the difference between any two successive test loads shall not exceed one fifth of the difference between the minimum and the maximum test loads. The series of test loads shall be applied to the elastic calibration device at least three times, and the shackles or bearing blocks shall be readjusted before each application of a series of loads.

Tolerance for Elastic Calibration Device

20. (*a*) For ordinary use the loading range of an elastic calibration device shall be that range of load within which any reading under an applied load shall not differ from the average of at least three readings under the same load by more than one fifth of 1 per cent.[1]

(*b*) The report of the verification of the elastic calibration device shall also state the loading range within which no reading varies from the average of at least three readings under the same load by more than one tenth of 1 per cent. This range shall be designated as the *Precision Loading Range* for the device.

Temperature Correction for Elastic Calibration Device

21. In using an elastic calibration device made of steel with not more than 5 per cent of alloying elements, a fairly accurate correction for variation in temperature may be made on the basis that the modulus of elasticity in tension or compression (or flexure) diminishes by 0.015 per cent for each degree Fahrenheit increase in temperature. For other metals, if the change in the modulus of elasticity with temperature is known, a correction for temperature should be applied to the readings of the instrument. During any calibration of a testing machine with an elastic calibrating device, or during the calibration of the device itself temperature shall be kept as uniform as possible.[2]

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[1] This means that the report of a standardizing laboratory on an elastic calibration device will state *within what loading range* it may be used, rather than reporting a blanket acceptance or rejection of the device. This follows the practice recommended for testing machines.

[2] Similar errors due to change of modulus of elasticity with temperature may be present in the load-indicating mechanism of a testing machine using a Bourdon gage or other device dependent on the elastic deformation of a member.

D. Verification by Companion Specimen Method

Description of Comparison Method

22. When the direct method of verification of a testing machine cannot be carried out (as is the case at present with horizontal testing machines, for example), or when an elastic calibration device is not available, a comparison method of verification may be used. In this method the machine to be verified is tested by comparing its indications with the corresponding readings obtained under the same conditions by the use of another testing machine, especially tested and verified, as specified in Section 23. The method of verification by comparison shall be carried out by the use of a series of companion specimens, half of which are to be tested in tension in the machine to be verified, and half of which are to be tested in tension in the especially verified testing machine which serves as a standard machine. The general provisions respecting the application of the test loads and the loading range which are outlined in the direct method of verifying testing machines (Sections 3, 4 and 5) shall apply to the verification of testing machines by the comparison method, so far as is practicable.

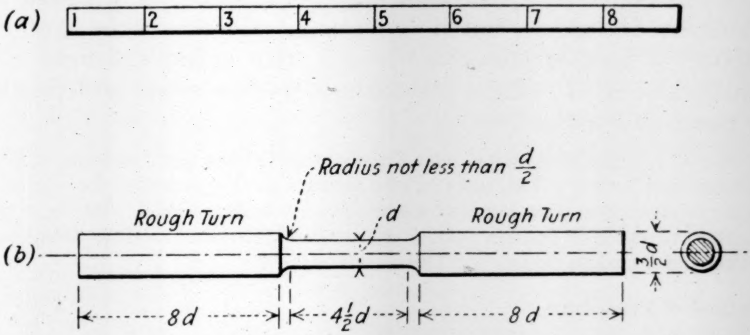

FIG. 2.—Companion Specimen.
(*a*) Method of Numbering Specimens.
(*b*) Form of Test Specimen.

Requirements for Testing Machines Used for Verifying Other Machines

23. (*a*) A testing machine which is to be used as the standard for verifying other testing machines shall itself be verified by a special test, in which the verification is carried out twice. The loading range shall be determined by the tolerance of ±1 per cent (Section 27). For the loading range established, the differences in indications found in the two tests of the standard machine shall not exceed 0.25 per cent.

(*b*) In verifying testing machines by the companion specimen method, corrections shall be applied to the indications of the standard machine and these corrections shall be based on the average correction obtained in the two tests used in its verification.

Test Specimens

24. (*a*) For each test load, eight or more tension test specimens shall be cut from soft rolled or drawn steel and numbered consecutively, as in Fig. 2 (*a*).

(*b*) The tensile strength of the steel shall be determined by a preliminary test and the sets of specimens for the comparison test shall have such nominal cross-sectional areas as will give, approximately, the loads required. The form of the specimen shall be as shown in Fig. 2 (*b*). The ends may be threaded, or otherwise machined, to fit holders, but it is recommended that those specimens shipped to another laboratory be left with cylindrical ends. The actual value of "*d*" (Fig. 2 (*b*)) for each specimen shall be determined by means of a micrometer.

NOTE.—It should be noted that the standard tension test specimen, 0.5 in. in diameter and having a 2-in. gage length, satisfies the requirements for a specimen for the verification of a testing machine by the comparison method. See Fig. 9 of the Standard Methods of Tension Testing of Metallic Materials (A.S.T.M. Designation: E 8) of the American Society for Testing Materials.[1]

Method of Procedure

25. (*a*) The specimens having odd numbers shall be tested in the machine to be verified and those having even numbers in the standard testing machine. The tensile strength only shall be determined.

(*b*) The speed of the testing machine, by which is meant the speed of the pulling head when the machine is running idle with no specimen in the machine, when testing verification specimens shall be approximately the same for both the standard testing machine and the machine being verified. The speed shall be the slowest speed that can be obtained on both machines; in any case the speed shall not exceed 1 in. per minute per inch of diameter of companion specimen.

(*c*) When testing companion specimens, especial care shall be taken to maintain the weighing beam of the testing machine in equilibrium as the tensile strength of the specimen is approached.

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[1] 1933 Book of A.S.T.M. Standards, Part I, p. 949.

It is recommended that a mark be placed at the middle of the trig loop and that a pointer be placed on the beam for verification tests, and that the pointer be kept as nearly on the mark as possible.

Computation of Error

26. (*a*) The average tensile strength (in pounds per square inch) of the odd-numbered specimens, multiplied by the nominal area of cross-section, shall be considered a measure of the indicated load, and the average tensile strength of the even-numbered specimens, multiplied by the nominal area of cross-section, shall be considered a measure of the applied load. The error shall be calculated from these data.

(*b*) If the tensile strength (in pounds per square inch) of any companion specimen varies more than 1 per cent from the mean of the group with which it is tested, its tensile strength shall not be used in computing the error of the testing machine. If more than one specimen in the odd-numbered group or more than one specimen in the even-numbered group exceeds the allowable variation in tensile strength, all the specimens shall be discarded and another set prepared.

TOLERANCES FOR TESTING MACHINES THAT MEASURE LOAD

Tolerance Within Loading Range of a Testing Machine

27. The error for loads within the loading range of a testing machine shall not exceed 1 per cent.

NOTE.—This means that the report of the verification of a testing machine will state *within what loading range it may be used*, rather than reporting a blanket acceptance or rejection of the machine.

Corrections

28. The indicated load of a testing machine shall not be corrected either by calculation or by the use of a calibration diagram to obtain values within the required tolerance.

TIME INTERVAL BETWEEN VERIFICATIONS

Time Interval Between Verifications

29. It is recommended that testing machines, when in constant use, be verified at intervals of six months and, when used intermittently, at intervals of two or three years. Testing machines shall, however, be verified immediately after making repairs or adjustments of the weighing mechanism, and whenever there is reason to doubt the accuracy of the results, without regard to the time interval since the last verification.

REPORTS AND CERTIFICATES

Reports

30. A clear and complete report shall be prepared of each verification of a testing machine. This report shall state the method of verification used, and shall give the serial numbers and the names of manufacturers of all apparatus used in carrying out the verification. It shall state how and by whom and when the calibration of the apparatus used in verifying the testing machine was made, the loading range, and the "precision" loading range of the calibration apparatus, and of the testing machine.

Certificates

31. A certificate giving the manufacturer's serial number and a brief description of the testing machine, the manufacturer's name, the date of verification, and the loading range, shall be signed by the person responsible for the maintenance of the testing machine, and this certificate shall be posted in plain view of a person operating the testing machine.

TENTATIVE REVISIONS
OF
A.S.T.M. STANDARDS

Tentative revisions of A.S.T.M. Standards are printed for one or more years with a view of eliciting criticisms, of which the committee concerned will take due cognizance before recommending final action.

Members of the Society and others are invited to direct written criticisms of any of these Tentative Revisions to the officer of the appropriate committee, whose name and address appear in the footnote in connection with each revision.

TENTATIVE REVISIONS OF A.S.T.M. STANDARDS

Revision of Standard Specifications for Structural Steel for Bridges (A.S.T.M. Designation: A 7 – 33):[1]

The Tentative Specifications for Steel for Bridges (A 7 – 33 T)[2] are in effect a tentative revision of and are intended to replace when adopted the present Standard Specifications A 7 – 33.

Revision of Standard Specifications for Structural Steel for Buildings (A.S.T.M. Designation: A 9 – 33):[1]

The Tentative Specifications for Steel for Buildings (A 9 – 33 T)[3] are in effect a tentative revision of and are intended to replace when adopted the present Standard Specifications A 9 – 33.

Revision of Standard Specifications for Quenched-and-Tempered Carbon-Steel Axles, Shafts, and Other Forgings for Locomotives and Cars (A.S.T.M. Designation: A 19 – 27):[1]

Section 5.—Change from its present form: namely,

5. (*a*) Unless otherwise specified by the purchaser, all forgings over 7 in. in diameter shall be bored, and all axles, shafts and similar forgings shall be rough-turned all over. The boring shall be done before quenching.

(*b*) If boring is specified, the diameter of the hole shall be at least 20 per cent of the maximum outside diameter or thickness of the forging, exclusive of collars and flanges.

to read as follows:

5. (*a*) Unless otherwise specified by the purchaser, all axles, shafts and similar forgings having a minimum diameter over 7 in. shall be bored. The boring shall be done before quenching.

(*b*) In the case of boring, the diameter of the hole, unless otherwise specified, shall be at least 20 per cent of the maximum outside diameter of the forging, exclusive of collars and flanges.

Revision submitted, June, 1931.

Revision of Standard Specifications for Quenched-and-Tempered Alloy-Steel Axles, Shafts, and Other Forgings for Locomotives and Cars (A.S.T.M. Designation: A 63 – 27):[1]

Section 5.—Make the same change in this section as recommended in Section 5 of Specifications A 19 – 27 above.

Revision submitted, June, 1931.

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[1] 1933 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. H. P. Bigler, Secretary of Committee A-1 on Steel, Rail Steel Bar Assn., 33 N. La Salle St., Chicago, Ill.

[2] See p. 511.

[3] See p. 519.

Revision of Standard Specifications for Cold-Drawn Steel Wire for Concrete Reinforcement (A.S.T.M. Designation: A 82 – 33):[1]

Section 4.—Change the table of minimum requirements appearing in Paragraph (*a*) to read as follows by the addition of the italicized words and figures:

Tensile strength, lb. per sq. in.	80 000
Yield point, per cent of observed tensile strength	*80*
Reduction of area, per cent	30

Add the following as a new Paragraph (*c*), relettering the present Paragraph (*c*) as Paragraph (*d*):

(*c*) The yield point shall be determined by the drop of the beam or halt in the gage of the testing machine. In case no definite drop of the beam or halt in the gage is observed until final rupture occurs, the test shall be construed as meeting the requirement for yield point in Paragraph (*a*).

Revision submitted, June, 1933.

Section 8.—Change this section from its present form: namely,

8. The diameter of the wire shall not vary more than 0.003 in. from the size ordered.

to read as follows:

8. The dimensions of the wire, on any diameter, shall not vary more than 0.003 in. from the specified nominal diameter. The difference between the maximum and minimum diameters, as measured on any given cross-section of the wire, shall not be greater than 0.003 in.

Revision submitted, June, 1933.

Revision of Standard Specifications for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A.S.T.M. Designation: A 83 – 33):[1]

Section 17.—Change this section from its present form: namely,

17. The name or brand of the manufacturer, the grade of material from which it is made, whether lap-welded steel or iron, and the hydrostatic pressure in pounds at which it was tested shall be legibly stenciled on each tube.

to read as follows:

17. (*a*) The name or brand of the manufacturer, the grade of material from which it is made, whether seamless or lap-welded, and whether steel or iron, together with the hydrostatic pressure in pounds at which it was tested, shall be legibly stenciled on each tube 1¼ in. in outside diameter and over, provided the length is not under 3 ft.

(*b*) On tubes less than 1¼ in. in diameter and on all tubes under 3 ft. in length, the name or initials or brand of the manufacturer shall be legibly stenciled or indicated on a sticker applied on each tube.

Revision submitted, June, 1933.

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[1] 1933 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. H. P. Bigler, Secretary of Committee A-1 on Steel, Rail Steel Bar Assn., 33 N. La Salle St., Chicago, Ill.

Revision of Standard Specifications for Carbon-Steel Castings (A.S.T.M. Designation: A 27 – 24):[1]

The Tentative Specifications for Carbon-Steel Castings for Industrial, Railroad and Marine Uses (A 154 – 33 T)[2] are in effect a tentative revision of and are intended to replace when adopted the present Standard Specifications A 27 – 24 and A 87 – 27.

Revision of Standard Specifications for Carbon-Steel Castings for Railroads (A.S.T.M. Designation: A 87 – 27):[1]

The Tentative Specifications for Carbon-Steel Castings for Industrial, Railroad and Marine Uses (A 154 – 33 T)[2] are in effect a tentative revision of and are intended to replace when adopted the present Standard Specifications A 27 – 24 and A 87 – 27.

Revision of Standard Specifications for Chilled Cast-Iron Wheels (A.S.T.M. Designation: A 46 – 24):[3]

The Tentative Specifications for Chilled-Tread Cast-Iron Wheels (A 46 – 30 T)[4] are in effect a tentative revision of and are intended to replace when adopted the present Standard Specifications A 46 – 24.

Revision of Standard Specifications for Zinc-Coated (Galvanized) Iron or Steel Farm-Field and Railroad Right-of-Way Wire Fencing (A.S.T.M. Designation: A 116 – 30):[5]

The Tentative Specifications for Zinc-Coated (Galvanized) Iron or Steel Farm-Field and Railroad Right-of-Way Wire Fencing (A 116 – 32 T)[6] are in effect a tentative revision of and are intended to replace when adopted the present Standard Specifications A 116 – 30.

Revision of Standard Specifications for Zinc-Coated (Galvanized) Iron or Steel Barb Wire (A.S.T.M. Designation: A 121 – 30):[5]

The Tentative Specifications for Zinc-Coated (Galvanized) Iron or Steel Barb Wire (A 121 – 32 T)[6] are in effect a tentative revision of and are intended to replace when adopted the present Standard Specifications A 121 – 30.

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[1] 1933 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. H. P. Bigler, Secretary of Committee A-1 on Steel, Rail Steel Bar Assn., 33 N. La Salle St., Chicago, Ill.

[2] See p. 544.

[3] 1933 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. W. H. Rother, Secretary of Committee A-3 on Cast Iron, 1543 Fillmore Ave., Buffalo, N. Y.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 976 (1930); also 1933 Book of A.S.T.M. Tentative Standards, p. 159.

[5] 1933 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. James Aston, Secretary of Committee A-5 on Corrosion of Iron and Steel, Carnegie Institute of Technology, Pittsburgh, Pa.

[6] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, pp. 599, 606 (1932); also 1933 Book of A.S.T.M. Tentative Standards, pp. 128, 125.

Revision of Standard Methods of Chemical Analysis of Ferro-Alloys (A.S.T.M. Designation: A 104 – 27):[1]

The Tentative Methods of Chemical Analysis of Ferrotungsten and Ferromolybdenum (A 104 – 32 T)[2] are in effect a tentative revision of and are intended when adopted to be incorporated in the present Standard Methods A 104 – 27.

Revision of Standard Methods of Chemical Analysis of Manganese Bronze (A.S.T.M. Designation: B 27 – 19):[3]

Under the Determination of Manganese by the Persulfate Method, change the description under Method from its present form: namely,

> In a 250-cc. Erlenmeyer flask dissolve 1 g. of bronze in 24 cc. of the "solution for dissolving." Allow to stand on a steam bath or hot plate until entirely dissolved, and until the oxides of nitrogen are expelled. Add 15 cc. of $AgNO_3$ solution and 20 cc. of ammonium persulfate and leave on the steam bath until the solution has developed a full permanganate color and no bubbles can be seen to come off when the flask is given a whirling motion. Cool to below 25° C. in running water, and add 50 cc. of cold water. Titrate with standard sodium-arsenite solution to the disappearance of the pink color.

to read as follows:

> Adjust the size of sample to the expected percentage so that the portion taken does not contain more than 0.002 g. manganese. Place it in a 250-cc. Erlenmeyer flask with 24 cc. of the "solution for dissolving" and heat until solution is complete. Boil until oxides of nitrogen are expelled. Dilute to 100 cc. with boiling-hot water, add 20 cc. of $AgNO_3$ solution and 30 cc. of the persulfate solution, then remove to a moderately warm place to stand for a few minutes for complete development of the permanganic acid. Cool to below 25° C., and titrate with the standard arsenite solution to the disappearance of the pink color.

Revision submitted, June, 1928.

Revision of Standard Methods of Chemical Analysis of Brass Ingots and Sand Castings (A.S.T.M. Designation: B 45 – 27):[3]

The Tentative Method of Determination of Phosphorus in Copper-Base Alloys in Ingot Form for Sand Castings (B 45 – 33 T)[4] is in effect a tentative revision of and is intended when adopted to be incorporated in the present Standard Methods B 45 – 27.

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[1] 1933 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. Charles McKnight, Secretary of Committee A-9 on Ferro-Alloys, The International Nickel Co., 67 Wall St., New York City.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 641 (1932); also 1933 Book of A.S.T.M. Tentative Standards, p. 173.

[3] 1933 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. E. E. Thum, Secretary of Committee B-2 on Non-Ferrous Metals and Alloys, *Metal Progress*, 7016 Euclid Ave., Cleveland, Ohio.

[4] See p. 638.

Revision of Standard Specifications for Hydrated Lime for Structural Purposes (A.S.T.M. Designation: C 6 – 31):[1]

Section 12.—Change the second and fifth paragraphs from their present form: namely,

> The lime shall be made into a stiff putty with water and permitted to soak over night. It shall be molded in a ring such as is used with a Vicat needle, resting the specimen on a glass plate.
>
> If the penetration is less than standard, the sample may be removed from the mold, mixed with more water, and retested. If the penetration is more than standard, the sample shall be discarded and a new one prepared.

to read respectively as follows:

> The lime shall be made into a stiff putty with water, stirred vigorously with a trowel or spatula for three minutes and permitted to soak over night. It shall be stirred vigorously with a trowel or spatula for three minutes, molded in a rubber ring such as is used with a Vicat needle, resting the specimen on a glass plate.
>
> If the penetration is less than standard, the sample may be removed from the mold, mixed with more water, stirred vigorously with a trowel or spatula for three minutes, and retested. If the penetration is more than standard, the sample shall be discarded and a new one prepared.

Revision submitted, June, 1925.

Section 13.—Change the first paragraph to read as follows by the addition of the italicized words:

> 13. Plasticity shall be determined by means of the apparatus shown in Fig. 1 as follows: Three hundred grams of the sample shall be mixed with enough water to form a thick putty ***and stirred vigorously for 3 minutes with a trowel or spatula.*** After aging in a vessel covered with a damp cloth for not less than 16 nor more than 24 hours, this putty shall be ***stirred vigorously for 3 minutes with a trowel or spatula and*** adjusted to standard consistency, as defined in Section 12, with a permissible variation of ± 5 mm.

Revision submitted, June, 1928.

Revision of Standard Specifications for Cement-Concrete Sewer Pipe (A.S.T.M. Designation: C 14 – 24):[2]

Section 1.—Add the following footnote:

> *Caution.*—The consumer or purchaser is cautioned against using cement-concrete pipe where the sewage shows an acid reaction.

Revision submitted, June, 1924.

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[1] 1933 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. W. V. Brumbaugh, Secretary of Committee C-7 on Lime, 927 Fifteenth St., N. W., Washington, D. C.

[2] 1933 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. M. W. Loving, Secretary of Committee C-13 on Concrete Pipe, American Concrete Pipe Assn., 33 W. Grand Ave., Chicago, Ill.

Revision of Standard Specifications for Clay Fire Brick for Malleable Furnaces with Removable Bungs and for Annealing Ovens (A.S.T.M. Designation: C 63 - 28):[1]

These specifications contain requirements for softening point of clay refractories. Since this property of fire clay, fire brick and silica cement is now known as pyrometric cone equivalent it is proposed that the term "softening point" as it appears in these specifications be changed to read "pyrometric cone equivalent."

Revision submitted, June, 1933.

Revision of Standard Specifications for Clay Fire Brick for Stationary Boiler Service (A.S.T.M. Designation: C 64 - 28):[1]

Make the same change in these specifications as is recommended in Specifications C 63 - 28 above.

Revision submitted, June, 1933.

Revision of Standard Specifications for Clay Fire Brick for Marine Boiler Service (A.S.T.M. Designation: C 65 - 28):[1]

Make the same change in these specifications as is recommended in Specifications C 63 - 28 above.

Revision submitted, June, 1933.

Revision of Standard Method of Test for Refractory Materials Under Load at High Temperatures (A.S.T.M. Designation: C 16 - 20):[1]

Section 2 (d).—Add the following as a second paragraph of the present Paragraph (*d*):

If the optical pyrometer is used, observations shall be made by sighting into a refractory tube having a closed end in the same relative position to the test specimen as that specified for the thermocouple.

Revision submitted, June, 1933.

Revision of Standard Method of Test for Softening Point of Fire-Clay Brick (A.S.T.M. Designation: C 24 - 33):[1]

Title.—Change the title of this method to read as follows, by the addition of the italicized words and the omission of those in brackets:

Standard Method of Test for [Softening Point] *Determining the Pyrometric Cone Equivalent* of Fire-Clay *and Fire* Brick.

Revision submitted, June, 1931.

It is also proposed that the term "Orton cones" as it appears in this method be changed to read "Standard Pyrometric Cones."

Revision submitted, June, 1933.

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[1] 1933 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. C. E. Bales, Secretary of Committee C-8 on Refractories, Ironton Fire Brick Co., Ironton, Ohio.

Section 1.—Change the scope of this method from its present form: namely,

1. The object of this test is to determine the softening point of fire-clay brick, by comparison of test cones with standard Orton pyrometric cones heated in a suitable furnace.

to read as follows:

1. This method is intended for determining the pyrometric cone equivalent of fire clay, fire brick, silica cement and ground fire clay by comparison of test cones with Standard Pyrometric Cones under the conditions herein prescribed.

Revision submitted, June, 1931.

Section 3 (a).—Change the description of the test cones from its present form: namely,

3. (*a*) The sample thus prepared shall be thoroughly mixed and, after the addition of sufficient dextrine or glue and water, shall be formed into test cones in a metal mold in the shape of tetrahedrons measuring 5 mm. (3/16 in.) on the sides at the base and 25 mm. (1 in.) high.

to read as follows:

3. (*a*) The dried sample shall be thoroughly mixed and after the addition of sufficient dextrine, glue, gum tragacanth or other alkali-free organic binder and water, shall be formed into test cones in a metal mold in the shape of tetrahedrons 8 mm. (5/16 in.) on the sides at the base and 25 mm. (1 in.) in height.

Revision submitted, June, 1931.

Appendix.—Add the following cone temperature table as an Appendix to these methods:

The Temperature corresponding with the end points of those Standard Pyrometric Cones, which are used in connection with refractories, are as follows:

Cone	End Point Deg. Cent.	End Point Deg. Fahr.	Cone	End Point Deg. Cent.	End Point Deg. Fahr.
No. 15..........	1435	2615	No. 29..........	1640	2984
No. 16..........	1465	2669	No. 30..........	1650	3002
No. 17..........	1475	2687	No. 31..........	1680	3056
No. 18..........	1490	2714	No. 32..........	1700	3092
No. 19..........	1520	2768	No. 33..........	1745	3173
No. 20..........	1530	2786	No. 34..........	1760	3200
No. 23..........	1580	2876	No. 35..........	1785	3245
No. 26..........	1595	2903	No. 36..........	1810	3290
No. 27..........	1605	2921	No. 37..........	1820	3308
No. 28..........	1615	2939	No. 38..........	1835	3335

NOTE.—These temperatures, which were determined by Fairchild and Peters[a] for a heating rate of 150° C. per hour for cones Nos. 15 to 20, and of 100° C. per hour for cones Nos. 23 to 38, other conditions being the same as specified, apply satisfactorily for all the conditions of this test method, but do not apply to conditions of the commercial firing and use of refractory materials.

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[a] Fairchild and Peters, "Characteristics of Pyrometric Cones," *Journal*, Am. Ceramic Soc., Vol. 9, No. 11, p. 700, November, 1926.

Revision submitted, June, 1931.

Section 5.—Add to the table of heating rates following Paragraph (*a*) the following requirements for cones Nos. 36, 37 and 38, not heretofore provided for:

Time interval to cone	36	10 minutes
" " " "	37	4 "
" " " "	38	6 "

Revision submitted, June, 1932.

Section 6.—Change the expression, "softening point" as it appears in this section to read "pyrometric cone equivalent."

Revision submitted, June, 1933.

Revision of Standard Definitions for Clay Refractories (A.S.T.M. Designation: C 27 - 28):[1]

These definitions contain requirements for softening point of clay refractories. Since this property of fire clay, fire brick and silica cement is now known as pyrometric cone equivalent it is proposed that the term "softening point" as it appears in these definitions be changed to read "pyrometric cone equivalent."

Revision submitted, June, 1933.

Revision of Standard Definitions of Terms Relating to Refractories (A.S.T.M. Designation: C 71 - 31):[1]

Several definitions of terms published under the title "Tentative Definitions of Terms Relating to Heat Transmission of Refractories (C 71 - 31 T)"[2] are intended to be added when adopted to the present Standard Definitions C 71 - 31.

Revision of Standard Definitions of Terms Relating to the Gypsum Industry (A.S.T.M. Designation: C 11 - 28):[3]

Several definitions of terms published under the title "Tentative Definitions of Terms Relating to the Gypsum Industry (C 11 - 31 T)"[2] are intended to be added when adopted to the present Standard Definitions C 11 - 28.

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[1] 1933 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. C. E. Bales, Secretary of Committee C-8 on Refractories, Ironton Fire Brick Co., Ironton, Ohio.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, pp. 779, 749 (1931); also 1933 Book of A.S.T.M. Tentative Standards, pp. 373, 311.

[3] 1933 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. H. J. Schweim, Secretary of Committee C-11 on Gypsum, Gypsum Assn., 211 W. Wacker Drive, Chicago, Ill.

Revision of Standard Definition of the Term Sand (A.S.T.M. Designation: C 58 – 28):[1]

The Tentative Definition of the Term Aggregate (C 58 – 28 T)[2] is intended to be included, when adopted, with the present Standard Definition C 58 – 28.

Revision of Standard Definitions of Terms Relating to Structural Clay Tile (A.S.T.M. Designation: C 43 – 31):[3]

The Tentative Definitions of Terms Relating to Structural Clay Tile (C 43 – 33 T)[4] are in effect a tentative revision of and are intended to replace when adopted the present Standard Definitions C 43 – 31.

Revision of Standard Specifications and Tests for Structural Clay Load-Bearing Wall Tile (A.S.T.M. Designation: C 34 – 31):[3]

The Tentative Specifications for Structural Clay Load-Bearing Wall Tile (C 34 – 33 T)[5] are in effect a tentative revision of and are intended to replace when adopted the specification requirements in the present Standard C 34 – 31.

Revision of Standard Specifications and Tests for Structural Clay Fireproofing, Partition and Furring Tile (A.S.T.M. Designation: C 56 – 31):[3]

The Tentative Specifications for Structural Clay Non-Load-Bearing Tile (C 56 – 33 T)[6] are in effect a tentative revision of and are intended to replace when adopted the specification requirements in the present Standard C 56 – 31.

Revision of Standard Specifications and Tests for Structural Clay Floor Tile (A.S.T.M. Designation: C 57 – 31):[3]

The Tentative Specifications for Structural Clay Floor Tile (C 57 – 33 T)[7] are in effect a tentative revision of and are intended to replace when adopted the specification requirements in the present Standard C 57 – 31.

Revision of Standard Definitions of Terms Relating to Timber Preservatives (A.S.T.M. Designation: D 324 – 33):[8]

The following definition of the term "water-gas tar" is intended when adopted to be added to the Standard Definitions D 324 – 33:

Water-Gas Tar.—Tar produced in the manufacture of carbureted water gas by the decomposition of petroleum oil by heat in the presence of blue gas.

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[1] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. R. E. Hess, Secretary of Committee E-8 on Nomenclature and Definitions, 260 S. Broad St., Philadelphia, Pa.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 835 (1928); also 1933 Book of A.S.T.M. Tentative Standards, p. 457.

[3] 1933 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. F. E. Emery, Secretary of Committee C-10 on Hollow Masonry Building Units, Structural Clay Tile Assn., 8 W. 40th St., New York City.

[4] See p. 682. [5] See p. 674. [6] See p. 671. [7] See p. 667.

[8] 1933 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. J. A. Newlin, Secretary of Committee D-7 on Timber, U. S. Forest Products Laboratory, Madison, Wis.

Revision of Standard Specifications for Basic Carbonate White Lead (A.S.T.M. Designation: D 81 – 31):[1]

Section 2. (a) Dry Pigment.—Change this section to read as follows by the omission of the words in brackets and the addition of the italicized word:

2. (*a*) Dry Pigment.—The pigment [shall be the product made from metallic lead and] shall have a composition [corresponding approximately to] *approximating* the formula $2PbCO_3.Pb(OH)_2$. It [shall be thoroughly washed after corroding], shall be free from impurities [and adulterants], and shall meet the requirements given in Section 3.

Revision submitted, June, 1932.

Section 3.—Add the following to this section as a new Paragraph (*e*):

(*e*) *Semipaste Containing Volatile Thinner.*—The semipaste shall not be caked in the container and shall be readily stirred to a uniform mixture which shall mix readily with oil, turpentine, or mineral spirits to form a smooth paint of brushing consistency. The odor of the semipaste, as taken from the container, while drying or after drying, shall be not abnormally pungent or disagreeable.

The semipaste shall conform to the following requirements:

	MAXIMUM	MINIMUM
Pigment, per cent	....	87.5
Linseed oil, per cent	10.5	....
Volatile matter[a] and moisture, per cent	3.0	1.5
Moisture, per cent	0.7	....
Coarse particles and skins (total residue retained on a No. 325 sieve), per cent of the dry pigment	1.5	....

[a] The volatile matter shall be turpentine, mineral spirits, or any mixture thereof.

Revision submitted, June, 1933.

Revision of Standard Methods of Routine Analysis of White Linseed Oil Paints (A.S.T.M. Designation: D 215 – 29):[1]

Testing Non-Volatile Vehicle.—At the end of Section *A*, *Preparation of Fatty Acids*, add the following new paragraph:

Instead of the preceding method the following procedure may be used, especially with samples that give trouble by the former: To about 50 g. of paint in a porcelain casserole, add 30 cc. of aqueous 30 per cent NaOH and 125 cc. of ethyl alcohol, mix and evaporate on steam bath until residue is dry. Transfer to a 400-cc. beaker and boil with 200 cc. of water, add H_2SO_4 (sp. gr. 1.2) (25 cc. in excess), boil, stir, filter through large coarse paper, and drain. Scrape mass into a flask, shake violently with ether, centrifuge, decant into a separatory funnel, and wash with small amounts of water until free of H_2SO_4. Transfer ether solution to dry flask and leave over about 40 g. of anhydrous sodium sulfate until ether layer is clear. Decant the clear solution through filter paper into a dry 100-cc. flask. Pass a rapid current of dry air into the mouth of the flask and heat to a temperature below 75° C. on a dry hot plate until the ether is entirely removed. The fatty acids prepared as above should be kept in a stoppered flask and examined at once.

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[1] 1933 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. M. Rea Paul, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

Revision submitted, June, 1932.

Under Section (2), Mixed or Composite Pigments, in the paragraph on *Insoluble Matter*, add the following sentence between the fourth and fifth sentences from the end of the first paragraph:

In order to make sure that practically no silica is occluded by the $BaSO_4$ as finally weighed, especially with pigments high in siliceous matter, the following step may be taken at this point: Evaporate the HCl solution to dryness, and heat at about 150° C. for one-half to one hour; moisten the residue with concentrated HCl, dilute with 100 cc. of hot water, boil a few minutes, filter hot through paper, and wash thoroughly with hot water.

Revision submitted, June, 1932.

Also under (2) Mixed or Composite Pigments, in the second paragraph under "Total Lead (Antimony)," change the seventh sentence to read as follows by the addition of the italicized words and the omission of those in brackets:

[Moisten the residue with a few drops of HCl,] *To the residue add sufficient concentrated HCl to dissolve the* $PbSO_4$ *(with pigments containing considerable amounts of* $PbSO_4$*, it may be necessary to add 15 to 20 cc. of concentrated HCl)*, add about 50 cc. of hot water, boil a few minutes, filter hot through paper, and wash with hot water until washings give no test for lead.

Revision submitted, June, 1932.

In the procedure for *Total Zinc* under B. Quantitative Analysis, (2) Mixed or Composite Pigments, change Paragraph (*d*) to read as follows:

(*d*) With pigments containing ZnO and ZnS, the ZnO may be determined as follows: Weigh accurately 1 g. of the pigment, transfer to a 250-cc. beaker, moisten with alcohol, add about 100 cc. of 1 to 3 per cent acetic acid, stir vigorously but do not heat, cover, and let stand for 18 hours, stirring once every 5 minutes for the first half hour. Filter, wash with 1 to 3 per cent acetic acid followed by water until the washings give no test for zinc with $K_4Fe(CN)_6$ solution. Dilute the clear filtrate to about 200 cc. with water, add 30 cc. of HCl (1:2), and a small piece of litmus paper; add strong NH_4OH until slightly alkaline, render just acid with HCl, then add 3 cc. of concentrated HCl, heat nearly to boiling, and titrate with $K_4Fe(CN)_6$ solution as above. Calculate this result to Zn, subtract from total Zn, and calculate the difference to ZnS. (Any $ZnCO_3$ or $ZnSO_4$ is included in the ZnO.)

Revision submitted, June, 1932.

In the last sentence of the fourth paragraph at the end of the methods change the footnote to the procedure of the Federal Specifications Board to read as follows:

Federal Specifications Board, Federal Specification TT-P-36 for Paints; Lead-Zinc Base, Ready-Mixed and Semipaste, White and Tinted, p. 2: "The total lead dissolved in dilute acetic acid and hot ammonium acetate, weighed as lead sulfate, and this weight multiplied by the factor 0.883 shall be considered white lead. It is not possible to determine the amount of lead carbonate and lead sulfate when carbonates or sulfates or other metals, such as calcium, are present. Also neither basic lead carbonate nor basic lead sulfate are definite compounds. The factor to convert $PbSO_4$ to $(PbCO_3)_2Pb(OH)_2$ is 0.854, to convert $PbSO_4$ to $PbSO_4PbO$ is 0.868, and to convert $PbSO_4$ to $(PbSO_4)_2PbO$ is 0.913. The arbitrary factor used under this specification is the mean of the largest and smallest of these factors."

Revision submitted, June, 1932.

Revision of Standard Methods of Routine Analysis of Yellow and Orange Pigments Containing Chromium Compounds, Blue Pigments and Chrome Green (A.S.T.M. Designation: D 126 - 27):[1]

Under General Methods add the following paragraph as a new Section 1, renumbering the present sections accordingly:

1. *Treatment of Sample.*—Dry pigments if lumpy or not finely ground shall be ground to a fine powder for analysis. Large samples may be thoroughly mixed and a representative portion taken and powdered, if lumpy or not finely ground. The sample in all cases shall be thoroughly mixed before taking portions for analysis. Extracted pigments shall be ground to a fine powder, passed through a No. 80 sieve to remove any skins, and thoroughly mixed. The weighed portions of extracted pigments should be moistened with a little alcohol before adding reagents for analysis. All samples shall be preserved in stoppered bottles or containers.

Revision submitted, June, 1932.

Section 7.—Change the ninth sentence to read as follows by the addition of the italicized words and figures and the omission of the words in brackets:

[Render an aliquot portion acid with H_2SO_4, boil to expel any free oxygen, cool,] *Boil an aliquot portion vigorously for 10 to 15 minutes to expel H_2O_2, cool, acidify with H_2SO_4*, add an excess of standard $(NH_4)_2Fe(SO_4)_2.6H_2O$ solution and titrate back with 0.1 N $K_2Cr_2O_7$ solution, using $K_3Fe(CN)_6$ as outside indicator.

Revision submitted, June, 1932.

Also in this section change the second from the last sentence in the first paragraph to read as follows by the addition of the italicized words and the omission of those in brackets:

If iron or aluminum are not to be determined or are present in negligible amounts, the first NH_4OH precipitate may be dissolved in dilute HCl, oxidized with Na_2O_2, [acidified with H_2SO_4, boiled,] *boiled vigorously for 10 to 15 minutes to expel H_2O_2, cooled, acidified with H_2SO_4*, and CrO_3 determined volumetrically.

Revision submitted, June, 1932.

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[1] 1933 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. M. Rea Paul, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

Section 11.—In the third sentence change "20 cc." to read "25 cc."

Revision submitted, June, 1932.

Section 22.—Change from its present form: namely,

22. Make the test for water-soluble matter in accordance with Section 11.

to read as follows:

22. Transfer 2.5 g. of the pigment to a graduated 250-cc. flask, fill to the mark with water and stopper. Shake vigorously and let stand at room temperature for not less than 15 hours, shaking vigorously from time to time. Then let settle, filter through a dry filter paper and discard the first 25 cc. of the filtrate. Transfer 100 cc. of the clear filtrate to a weighed dish, evaporate to dryness on a steam bath, dry for one hour in an oven at 105 to 110° C., cool and weigh. Calculate the percentage of water-soluble matter.

Revision submitted, June, 1932.

Section 38.—Change to read as follows by the addition of the italicized words:

38. On a separate sample determine the sulfate directly with Na_2CO_3 as in the preceding paragraph, without any preliminary treatment with bromine water *or nitric acid.*

Revision submitted, June, 1932.

Section 53.—Change the reference from "Section 11" to read "Section 22."

Revision submitted, June, 1932.

New Methods.—Add the following Methods of Analysis of Chrome Oxide Green as Sections 55 to 57:

METHODS OF ANALYSIS OF CHROME OXIDE GREEN

Chrome oxide green is practically pure sesquioxide of chromium (Cr_2O_3) without any admixture.

Moisture

55. Determine moisture in accordance with Section 45.

Water-Soluble Matter

56. Determine water-soluble matter in accordance with Section 11.

Total Chromium

57. Mix thoroughly about 0.25 g. (accurately weighed) of the sample with approximately 5 g. of sodium peroxide (containing at least 90 per cent Na_2O_2) in a 30-cc. pure iron crucible (ordinary iron crucibles may contain some chromium and manganese) and fuse carefully over a gas flame. Five minutes fusion at a low red heat after the mass has melted will insure complete decomposition. Allow the crucible to partly cool, and while tightly covered, tap on an iron plate to loosen the fusion in a solid cake. Place the cake in a covered

beaker and dissolve with 200 cc. of warm water. Rinse the crucible and cover with warm water, adding to the main portion. Add approximately 1 g. of sodium peroxide and boil the solution for 10 minutes. Cool and acidify with sulfuric acid (50 cc., 1:1 sulfuric acid). A clear solution with a few scales of magnetic oxide should result. Immediately cool again, add 5 cc. of phosphoric acid (sirup, sp.gr. 1.725), transfer to an 800-cc. beaker and dilute with cold water to 500 cc. Add an accurately measured excess (about 100 cc.) of approximately 0.1 *N* ferrous ammonium sulfate to the solution while stirring. When reduction is complete a deep pure green color should develop, and a drop of the liquid when tested with a drop of dilute potassium ferricyanide solution should give a blue color. Set the beaker about ½ in. above a white tile to secure good light. Determine the excess of ferrous sulfate by titration with a standard solution (approximately 0.1 *N*) of potassium permanganate. Take the first faint permanent darkening of the clear green color as the end point. Addition of more permanganate increases the depth of the color which finally becomes purple. The end point is quite sharp and well defined, but requires some practice. If the ferrous salt has been standardized against dichromate, subtract the required number of cubic centimeters of 0.1 *N* permanganate from the number of cubic centimeters of 0.1 *N* ferrous solution. The difference represents the number of cubic centimeters of 0.1 *N* ferrous solution which multiplied by 0.001733 g. gives the grams of chromium present. Where the ferrous solution has been standardized against sodium oxalate, it is necessary to subtract a "blank" from the permanganate titration. This blank" is obtained as follows: When the end point is reached and the readings have been noted, add about 5 cc. excess of the ferrous solution and oxidize the excess of ferrous iron by adding 8 cc. of a 15 per cent solution of ammonium persulfate. Stir the liquid vigorously for one minute. Carefully add 0.1 *N* permanganate to the solution with constant stirring until the same end point is obtained as before. The volume of permanganate required, usually 0.2 to 0.4 cc., constitutes the "blank" to be deducted from the volume of the permanganate titration.

NOTE.—*Example:* In the determination of chromium in a 0.5000-g. sample 190.0 cc. of a 0.11 *N* ferrous solution and 11.00 cc. of a 0.1 *N* permanganate (11.40 − 0.4 cc. blank) were employed. The calculations are as follows:

$190.0 \times 1.100 = 209.0$ cc. of 0.1 *N* ferrous solution;
$209.0 - 11.00 = 198.00$ cc.
$198.0 \times 0.001733 \times 2 \times 100 = 68.62$ per cent Cr.

Revision submitted, June, 1932.

Revision of Standard Definitions of Terms Relating to Paint Specifications (A.S.T.M. Designation: D 16 – 24):[1]

Add the following three new definitions of terms:

Screen (*Sieve*).—A plate or sheet or a woven cloth, or other device, with regularly spaced apertures of uniform size, mounted in a suitable frame or holder, for use in separating material according to size.

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[1] 1933 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. M. Rea Paul, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

NOTE 1.—The shape and spacing of apertures, size of wires or threads, thickness of plate or sheet, allowable variations and similar properties should be taken care of in specifications.

NOTE 2.—In mechanical analysis testing work, when not otherwise specified, the term "sieve" shall apply to an apparatus in which the apertures are rectangular, and the term "screen" shall apply to an apparatus in which the apertures are circular.

Toughness.—That quality of a material which may be measured by the maximum impact which it will withstand without rupture.

Elasticity.—In the case of paint or varnish, that property which allows a film to follow, without rupture, changes in the extent and form of the surface to which it is applied.

Revision submitted, June, 1925; Modified, June, 1928.

Revision of Standard Method of Test for Cloud and Pour Points (A.S.T.M. Designation: D 97 - 33):[1]

Section 9.—Change this section to read as follows by the addition of the italicized words and the omission of those in brackets. No change is proposed in the note following this section.

9. The cooling bath, g, shall be of a type suitable for obtaining the required temperatures. The size and shape of the bath are optional but a support, suitable for holding the jacket firmly in a vertical position, is essential. [For determination of very low pour points, a smaller insulated cooling bath may be used and the test jar placed directly in it.] *For determination of pour points below 50 F. two or more baths should be at hand.* The required bath temperatures may be maintained by refrigeration if available, otherwise by suitable freezing mixtures.

Revision submitted, June, 1933.

Section 10.—Change the fifth and sixth paragraphs of Section 10 to read as follows by the addition of the italicized words and the omission of those in brackets:

[The temperature of the cooling bath, g, shall be adjusted so that it is below the cloud point of the oil by not less than 15 nor more than 30 F. and this temperature shall be maintained throughout the test.] *The temperature of the cooling bath, g, shall be maintained at not lower than 30 F.* The jacket containing the test jar shall be supported firmly in a vertical position in the cooling bath so that not more than 1 in. of the jacket projects out of the cooling medium.

At each test thermometer reading which is a multiple of 2 F., the test jar shall be removed from the jacket, quickly but without disturbing the oil, inspected for cloud, and replaced in the jacket. This complete operation shall require not more than three seconds. [If the oil does not show a cloud when it has been cooled to 15 F., the test jar shall be placed directly in a cooling bath of suitable temperature.] *If the oil does not show a cloud when it has been cooled to 50 F., the test jar shall be placed in a second bath maintained at a temperature*

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[1] 1933 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. R. P. Anderson, Secretary of Committee D-2 on Petroleum Products and Lubricants, American Petroleum Inst., 250 Park Ave., New York City.

not lower than 0 F. If the oil does not show a cloud when it has been cooled to 20 F., the test jar shall be placed in a third bath maintained at a temperature not lower than −30 F.

Revision submitted, June, 1933.

Section 11.—Change the sixth and seventh paragraphs of Section 11 to read as follows by the addition of the italicized words and the omission of those in brackets:

[The temperature of the cooling bath, g, shall be adjusted so that it is below the pour point of the oil by not less than 15 nor more than 30 F. and this temperature shall be maintained throughout the test.] *The temperature of the cooling bath, g, shall be maintained at not lower than 30 F.* The jacket, containing the test jar, shall be supported firmly in a vertical position in the cooling bath so that not more than 1 in. of the jacket projects out of the cooling medium.

Beginning at a temperature 20 F. before the expected pour point, at each test thermometer reading which is a multiple of 5 F., the test jar shall be removed from the jacket carefully and shall be tilted just enough to ascertain whether there is a movement of the oil in the test jar. The complete operation of removal and replacement shall require not more than 3 seconds. [If the oil has not ceased to flow when its temperature has reached 15 F., the cold test jar shall be placed directly in a cooling bath of suitable temperature.] *If the oil has not ceased to flow when its temperature has reached 50 F., the test jar shall be placed in the jacket in a second bath maintained at a temperature not lower than 0 F. If the oil has not ceased to flow when its temperature has reached 20 F., the test jar shall be placed in the jacket in a third bath maintained at a temperature not lower than −30 F. For determinations of very low pour points, additional baths should be maintained with successively lower temperature differentials of about 30 F. In each case the test jar shall be transferred when the temperature of the oil reaches a point 50 F. above the temperature of the new bath. At no time shall the cold test jar be placed directly in the cooling medium.* As soon as the oil in the test jar does not flow when the jar is tilted, the test jar shall be held in a horizontal position for exactly 5 seconds, as noted by a stop watch or other accurate timing device, and observed carefully. If the oil shows any movement under these conditions, the test jar shall be immediately replaced in the jacket [if the temperature of the oil is above 15 F., or directly in the cooling bath if the temperature is below 15 F.,] and a test for flow repeated at the next temperature 5 F. lower.

Revision submitted, June, 1933.

Revision of Standard Specifications for Broken Slag for Waterbound Base and Wearing Course (A.S.T.M. Designation: D 65 – 23):[1]

Section 4.—Omit this section, reading as follows, renumbering the subsequent sections accordingly:

4. The percentage of wear shall be not more than 12.0 per cent.

Revision submitted, June, 1924.

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[1] 1933 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, Asphalt Inst., 801 Second Ave., New York City.

Section 6.—Change the last line of this section to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

[Retained on] *Passing* 2½-in. screen . . . not [less] *more* than [85] *15* per cent.

Revision submitted, June, 1924.

Section 7 (b).—Omit this paragraph which refers to the method for determining the percentage of wear.

Revision submitted, June, 1924.

Revision of Standard Specifications for Shovel-Run or Crusher-Run Broken Slag for Waterbound Base (A.S.T.M. Designation: D 66 – 23):[1]

Section 4.—Omit this section, reading as follows, renumbering the subsequent sections accordingly:

4. The percentage of wear shall be not more than 15.0 per cent.

Revision submitted, June, 1924.

Section 6 (b).—Omit this paragraph which refers to the method for determining the percentage of wear.

Revision submitted, June, 1924.

Revision of Standard Specifications for Block for Granite Block Pavements (A.S.T.M. Designation: D 59 – 26):[1]

Section 3 (a).—Change to read as follows by the addition of the italicized words:

3. (*a*) The percentage of wear and the French coefficient of wear shall be determined in accordance with the Standard Method of Test for Abrasion of Rock (A.S.T.M. Designation: D 2) of the American Society for Testing Materials, *except that the sample shall be prepared by use of a press and the fragments shall be as uniform and as nearly cubical as practicable.*

Revision submitted, June, 1929.

Revision of Standard Specifications for Block for Recut Granite Block Pavements (A.S.T.M. Designation: D 131 – 23):[1]

Section 3 (a).—Make the same change in this section as recommended in Section 3 (*a*) of Specifications D 59 – 26 above.

Revision submitted, June, 1929.

Revision of Standard Specifications for Block for Durax Granite Pavements (A.S.T.M. Designation: D 132 – 23):[1]

Section 3 (a).—Make the same change in this section as recommended in Section 3 (*a*) of Specifications D 59 – 26 above.

Revision submitted, June, 1929.

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[1] 1933 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, Asphalt Inst., 801 Second Ave., New York City.

Revision of Standard Specifications for Tolerances for Hose Ducks and Belt Ducks (A.S.T.M. Designation: D 181 – 33):[1]

Title.—Change the title of this standard by the addition after the word "tolerances" of the phrase "and test methods."

Revision submitted, June, 1933.

Methods of Testing.—Add the following methods of testing as Sections 9 to 15, inclusive, of this standard:

METHODS OF TESTING

9. All test procedure not covered in these specifications shall be in accordance with the Standard General Methods of Testing Woven Textile Fabrics (A.S.T.M. Designation: D 39) of the American Society for Testing Materials.

10. *Width.*—The average width shall be determined by measuring at five different places uniformly distributed along the full length of the roll. No measurement shall be considered within 3 yd. of either end of the roll.

11. *Weight.*—(*a*) The net weight of the roll from which the covering has been removed shall be determined.

(*b*) The standard weight of the full roll shall be determined from the following formula:

$$\text{Standard weight} = \frac{\text{Actual width} \times \text{Basic weight} \times \text{Length}}{\text{Basic width} \times 16}$$

(*c*) Comparison of the net weight with the standard weight of the full roll shall be used in determining the percentage light or heavy.

12. *Count.*—The average number of ends and picks per inch of the fabric shall be determined by counting a space not less than 1 in. in five different places uniformly distributed along the full length of the roll. No count shall be considered within 6 in. of the selvages nor within 3 yd. of either end of the roll.

13. *Thickness* (*Gage*).—The average thickness of the fabric shall be determined by means of an automatic micrometer equipped with a foot ⅜ in. in diameter. The foot of the micrometer shall be raised ¼ in. above the fabric and allowed to drop under a dead weight pressure of 6 oz. The gage shall be taken in five different places uniformly distributed along the full length of the roll. No gage shall be considered within 6 in. of the selvages nor within 3 yd. of either end of the roll.

14. *Crimp.*—(*a*) The average crimp of warp or filling shall be determined by testing at least four adjacent samples each of warp and filling yarns under standard conditions.

(*b*) The yarns for test shall be taken from the inside edge of the test piece as near the center line of the roll as possible.

(*c*) The yarns shall then be straightened by a machine which applies a definite tension of 150 g.

15. *Tensile Strength.*—(*a*) The average tensile strength shall be determined by testing five samples each of warp and filling on any standard type of inclination balance machine of 400- and 800-lb. capacities.

(*b*) The lower capacity of the testing machine shall be used until the swing of the pendulum exceeds an angle of 45 deg. from the vertical. When the fabric breaks above this mark, the higher capacity of the testing machine shall be used. The speed of the pulling jaw shall be 12 in. per minute. The length of the test specimen between nip of jaws shall be 3 in.

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[1] 1933 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. W. H. Whitcomb, Secretary of Committee D-13 on Textile Materials, Interlaken Mills, West Warwick, R. I.

(*c*) Tensile strength shall be determined by the Grab Test as defined in Section 12 of the Standard General Methods of Testing Woven Textile Fabrics (A.S.T.M. Designation: D 39) of the American Society for Testing Materials, the samples for testing having been brought to a standard condition as defined in Section 3 of the Standard Methods D 39.

Revision submitted, June, 1933.

Revision of Standard Specifications for Tolerances and Test Methods for Certain Light and Medium Cotton Fabrics (A.S.T.M. Designation: D 274 – 29):[1]

Tear Resistance Test.—Add the following new tear resistance test procedure as Section 8:

Tear Resistance

8. (*a*) *Preferred Method.*—A specimen 3 in. in width and 6 in. in length shall be selected for test. An isosceles trapezoid having an altitude of 3 in. and with bases 1 in. and 4 in. in length, respectively, shall then be marked on the specimen with the aid of a template. A cut ¼ to ⅜ in. in length shall then be made in the center of the 1-in. length and perpendicular to it. The specimen shall then be clamped in the jaws of the tensile strength testing machine along the non-parallel sides of the trapezoid. The initial distance between the jaws shall be 1 in., and the width of the jaws shall be 3 in. or more. One edge of the specimen shall thus be held taut while the other edge lies in folds. The machine shall then be started and the sample torn, the speed of the pulling jaw being 12 in. per minute. The pawl on the pendulum shall be disengaged from the ratchet during the test. The average load necessary to continue the tear after it has been started shall be considered as the tear resistance of the fabric. The average of five determinations in the warp and five in the filling directions shall be reported. The capacity of the machine should be such that the specimen tears in the range of maximum sensitivity.

(*b*) *Alternate Method.*—A specimen 3 in. in width and 8 in. in length shall be selected for test. A longitudinal cut 3 in. in length shall be made in the center of the specimen. One of the tongues thus formed shall be placed in the upper jaw of a tensile strength testing machine, preferably with automatic recording device, and the other in the lower jaw. The machine shall then be started and the specimen torn, the speed of the pulling jaw being 12 in. per minute. The pawl on the pendulum shall be disengaged from the ratchet during the test. The average load necessary to continue the tear after it has been started shall be considered to be the tear resistance of the fabric. The average of five determinations in the warp and five in the filling directions shall be reported. The capacity of the machine should be such that the specimen tears in the range of maximum sensitivity.

Revision submitted, June, 1930; Modified, June, 1933.

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[1] 1933 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. W. H. Whitcomb, Secretary of Committee D-13 on Textile Materials, Interlaken Mills, West Warwick, R. I.

Shrinkage Test.—Add the following new shrinkage test procedure as Sections 9 to 13, inclusive:

Shrinkage Test

9. *Test Sample.*—The sample for the shrinkage test shall be at least 20 in. square, and shall be cut from the fabric in such a way as to be fairly representative of the material, or it may be a piece 20 in. in length and the full width of the goods. There shall be marked off accurately on the sample, in both the warp and filling directions, three 18-in. lengths by means of fine indelible ink lines or by fine threads sewed into the fabric. Care shall be taken to see that the marks run parallel with the threads.

10. *Apparatus.*—The washing shall preferably be carried out in a reversing wash wheel of the cylindrical type. The wheel shall be equipped with a steam pipe so that the water can be heated directly in the wheel by means of live steam. A standard load shall consist of approximately 3 lb. of dry samples and an amount of water equal to 50 times the weight of the samples. The proportion of water may be increased if necessary to insure that the samples are thoroughly covered.

11. *Soap Solution.*—An amount of laundry soap of good grade shall be used sufficient to make a good running suds. The soap shall be dissolved before adding it to the wash wheel. A good stock solution can be made by thoroughly dissolving 1 lb. of chip soap in 1 gal. of hot water.

12. *Procedure.*—The shrinkage test shall be carried out in accordance with Paragraphs (*a*) to (*c*). During the shrinkage test procedure, which requires exactly 60 minutes, the wash wheel shall be kept running continuously.

(*a*) *Washing.*—Place the samples to be tested in the wheel and start it. Turn on the water and the steam. If steam is not available, heat the water separately and add it to the wheel. Fill the wheel to the proper water level and then add the soap. Turn off the steam when the water boils (212 F., 100 C.). Allow the wheel to run for 40 minutes from the time it started, and then draw off the water. Fill the wheel again to the proper level with water and raise its temperature to 140 F. (60 C.). Run the wheel for 5 minutes, and then draw off the water. Fill the wheel again to the proper level with water and raise its temperature to 140 F. (60 C.). Run the wheel for 10 minutes. Draw off the water and run the wheel for 5 minutes, tumbling the wet samples in the wheel while the water drains.

(*b*) *Drying.*—Remove the samples from the wheel, *squeezing* the excess water from them by hand. Do not wring the samples by hand or by means of a wringer, as either method may distort the material and give unsatisfactory results. Spread the samples horizontally to dry on a screen or ventilated surface. Do not hang the samples vertically to dry. If available, dry the samples in a heated drying chamber, otherwise in a current of air at room temperature from an electric fan. When the samples are dry, lay them out smoothly without stretching on a table, and dampen. Allow them to condition for 5 minutes.

(*c*) *Pressing.*—Two methods of pressing shall be recognized, by means of a hand iron or by means of a flat bed press, as follows:

Hand Pressing.—Lay out the conditioned samples on a padded ironing table, carefully smooth out all noticeable wrinkles, and press by raising and lowering the iron. Do not slide the iron back and forth on the samples as this may distort the cloth. Allow the samples to cool, and then measure them carefully to determine any changes in the marked lengths.

Machine Pressing.—Lay out the conditioned samples on the bed of the press, carefully smooth out all noticeable wrinkles, and press by lowering the head of the machine. Remove samples from the bed of the machine in such a manner as to cause no strain on the cloth. Allow the samples to cool, and then measure them carefully to determine any changes in the marked lengths.

13. *Results.*—The results shall be reported separately for both warp and filling directions, and shall be the average obtained from the three marked lengths. The results may be expressed in inches per yard or as a percentage of the original length.

Revision submitted, June, 1933.

Revision of Standard General Methods of Testing Woven Textile Fabrics (A.S.T.M. Designation: D 39 – 27):[1]

Section 13.—Replace the last sentence of this section, which reads as follows:

> The crimp shall be the ratio between the final length of the thread and its original length in the cloth.

by the following sentence:

> The crimp shall be the difference in distance between two points of the yarn as it lies in the fabric, and the same two points when the yarn has been removed from the fabric and straightened, expressed as a percentage of the distance between the two points as the yarn lies in the fabric.

Revision submitted, June, 1933.

Tear Resistance Test.—Add as a new Section 14 the tear resistance test procedure recommended in Specifications D 274 – 29 above.

Revision submitted, June, 1930; Modified, June, 1933.

Elongation Test.—Add the following new elongation test procedure as Section 15:

Elongation

15. Unless otherwise specified, the elongation of cloth at any stated load shall be obtained when the breaking strength is determined and for the same specimens by means of a suitable autographic recording device on the testing machine. The elongation shall be the average of the results obtained for five specimens. It shall be expressed as the percentage increase in length. Since the initial length and therefore the measured elongation depend upon the load applied in placing the specimen in the jaws of the machine, an initial load just under that required to register on the dial of the machine should be used. In practice, it is advantageous to place the specimen in the machine at a somewhat lower load and to calculate the initial length of the specimen from the distance between the jaws of the machine when the test is started and the distance the jaws separate before a just perceptible load is assumed by the specimen, as shown by the graphic record.

Revision submitted, June, 1933.

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[1] 1933 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. W. H. Whitcomb, Secretary of Committee D-13 on Textile Materials, Interlaken Mills, West Warwick, R. I.

Revision of Standard Methods of Testing Electrical Porcelain (A.S.T.M. Designation: D 116 - 30):[1]

Sections 31 to 34, inclusive.—Change the porosity (water absorption) test from its present form, to read as follows:

POROSITY

31. *Scope.*—(*a*) In the case of relatively coarse and porous bodies, the porosity of porcelain may be indicated by the amount of water which they absorb, expressed as percentage (by weight) water absorption. Method A, described in Sections 32 to 34, is intended to be used for such cases and shall be used whenever the value of water absorption is 0.1 per cent or over.

(*b*) In the case of the more dense porcelain bodies, the porosity of porcelain may be indicated by the amount of gas contained in a sample of known volume, expressed as percentage (by volume) pore volume. Method B, described in Sections 35 to 40, is intended to be used for such cases and shall be used whenever the value of water absorption (Method A) is less than 0.1 per cent.

A. Water Absorption

32. *Apparatus.*—The apparatus shall consist of the following:

(*a*) A chemical balance; and

(*b*) An oven capable of maintaining a temperature of 120 C. ± 5 C. (248 F. ± 9 F.).

33. *Specimens.*—(*a*) The specimen used shall weigh from 20 to 50 g. and shall have at least 25 per cent of the surface newly fractured.

(*b*) Not less than five specimens shall be tested.

34. *Procedure.*—(*a*) Each specimen shall be dried for two hours in the oven at 120 C. (248 F.), then cooled in a desiccator to the approximate room temperature and weighed immediately.

(*b*) The specimen shall then be transferred to a beaker of briskly boiling distilled water and allowed to remain totally submerged therein for 30 minutes. It shall then be removed and quenched in distilled water at room temperature (about 20 C., 68 F.). The surface water shall be wiped off with a soft cloth and the specimen weighed immediately.

35. *Report.*—The report shall include the following:

(*a*) The dry weight of each specimen.

(*b*) The weight of each specimen after immersion.

(*c*) The percentage water absorption of each specimen.

(*d*) The average percentage water absorption of all specimens tested.

Revision submitted, June, 1933.

Power Factor, Dielectric Strength and Resistivity.—To provide specific reference to the available tests for these properties, the following Sections 42 and 43 are recommended for inclusion in the methods:

POWER FACTOR AND DIELECTRIC CONSTANT

42. The power factor and dielectric constant shall be determined in accordance with the Tentative Methods of Testing Electrical Insulating Materials for Power Factor and Dielectric Constant (A.S.T.M. Designation: D 150 - 32 T) of the American Society for Testing Materials.

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[1] 1933 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. J. A. Scott, Secretary of Committee D-9 on Electrical Insulating Materials, General Electric Co., Schenectady, N. Y.

RESISTIVITY

43. The resistivity shall be determined in accordance with the Standard Methods of Test for Resistivity of Insulating Materials (A.S.T.M. Designation: D 257) of the American Society for Testing Materials.

Revision submitted, June, 1933.

Revision of Standard Method of Test for Size of Anthracite (A.S.T.M. Designation: D 310 - 31):[1]

Section 3.—Change this section to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

3. The screen openings for testing the different commercial sizes of anthracite[a] shall be as follows:

SIZE	SIZE OF ROUND-HOLE OPENINGS IN TESTING SCREENS
Broken	Passing a [$4\frac{7}{16}$] *$4\frac{3}{8}$*-in. screen, retained on a [$3\frac{7}{16}$] *$3\frac{1}{4}$*-in. screen
Egg	Passing a [$3\frac{7}{16}$] *$3\frac{1}{4}$*-in. screen, retained on a [$2\frac{8}{16}$] *$2\frac{7}{16}$*-in. screen
Stove	Passing a [$2\frac{8}{16}$] *$2\frac{7}{16}$*-in. screen, retained on a [$1\frac{9}{16}$] *$1\frac{5}{8}$*-in. screen
Chestnut	Passing a [$1\frac{9}{16}$] *$1\frac{5}{8}$*-in. screen, retained on a [$\frac{11}{16}$] $\frac{13}{16}$-in. screen
Pea	Passing a [$\frac{12}{16}$] $\frac{13}{16}$-in. screen, retained on a [$\frac{8}{16}$] $\frac{9}{16}$-in. screen
No. 1 Buckwheat	Passing a $\frac{9}{16}$-in. screen, retained on a $\frac{5}{16}$-in. screen
No. 2 Buckwheat (Rice)	Passing a $\frac{5}{16}$-in. screen, retained on a $\frac{3}{16}$-in. screen
No. 3 Buckwheat (Barley)	Passing a $\frac{3}{16}$-in. screen, retained on a $\frac{3}{32}$-in. screen

Tolerances of ± 3 per cent on average openings and of 10 per cent in maximum openings are permissible.

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[a] The names of anthracite sizes and the size of screen openings [for broken, egg, stove, chestnut, and pea sizes] are in conformity with those recommended by the Anthracite [Operators' Conference of August 8, 1929] *Institute as approved March 18, 1931, and made effective April 1, 1931.*

Revision submitted, September, 1933.

Revision of Standard Definitions of Terms Relating to Coal and Coke (A.S.T.M. Designation: D 121 - 30):[1]

The Tentative Definition of the Term Coke (D 121 - 30 T)[2] is intended to be added when adopted to the present Standard Definitions D 121 - 30.

Revision of Standard Definitions of Terms Relating to Methods of Testing (A.S.T.M. Designation: E 6 - 30):[3]

The definitions of the terms "elastic limit" and "yield strength" published under the title "Tentative Definitions of Terms Relating to Methods of Testing (E 6 - 32 T)[4] are intended to be added when adopted to the present Standard Definitions E 6 - 30.

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[1] 1933 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. W. A. Selvig, Secretary of Committee D-5 on Coal and Coke, U. S. Bureau of Mines, 4800 Forbes St., Pittsburgh, Pa.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 1147 (1930); also 1933 Book of A.S.T.M. Tentative Standards, p. 471.

[3] 1933 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. H. F. Moore, Chairman of the Technical Committee on Mechanical Testing of Committee E-1 on Methods of Testing, University of Illinois, Urbana, Ill.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 967 (1932); also 1933 Book of A.S.T.M. Tentative Standards, p. 1059.

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